California Academy of Sciences

RECEIVED BY PURCHASE

23416

Digitized by the Internet Archive
in 2011 with funding from
California Academy of Sciences Library

http://www.archive.org/details/transactionsofge22geol

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF LONDON.

SECOND SERIES.

VOLUME II.

Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant.

Novum Organum, Præfatio.

LONDON:

PRINTED BY RICHARD TAYLOR, RED LION COURT, FLEET STREET.

SOLD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, SOMERSET HOUSE.

1829.

OFFICERS AND COUNCIL OF THE GEOLOGICAL SOCIETY OF LONDON.

1826.

PRESIDENT.

JOHN BOSTOCK, M.D. F.R.S. L.S. & H.S.

VICE-PRESIDENTS.

Rev. WILLIAM DANIEL CONYBEARE, F.R.S.
Sir ALEXANDER CRICHTON, M.D. F.R.S. & L.S. Hon. Memb. Imp. Acad. St. Petersburgh.
WILLIAM HENRY FITTON, M.D. F.R.S.
CHARLES STOKES, Esq. F.R.S. S.A. & L.S.

SECRETARIES.

WILLIAM JOHN BRODERIP, Esq, F.L.& H.S.
RODERICK IMPEY MURCHISON, Esq. F.R.S.

FOREIGN SECRETARY.

HENRY HEULAND, Esq.

TREASURER.

JOHN TAYLOR, Esq. F.R.S.

COUNCIL.

ARTHUR AIKIN, Esq. F.L.S.
HENRY THOMAS DE LA BECHE, Esq. F.R.S. & L.S.
J. E. BICHENO, Esq. Sec. L.S.
H. T. COLEBROOKE, Esq. F.R.S. L. & E. F.L. & Asiat. Soc.
Sir CHARLES HENRY COLVILLE.
GEORGE BELLAS GREENOUGH, Esq. F.R.S. L.S. & H.S.
Sir CHARLES LEMON, Bart. F.R.S.
ARMAND LEVY, Esq.
CHARLES LYELL, Esq. F.R.S. & L.S.
WILLIAM HASLEDINE PEPYS, Esq. F.R.S. L.S. & H.S.
GEORGE POULETT SCROPE, Esq.
J. F. VANDERCOM, Esq.
HENRY WARBURTON, Esq. F.R.S.

HOUSE SECRETARY, AND CURATOR.

THOMAS WEBSTER, Esq.

ADVERTISEMENT.

THE Editors of the Transactions of the Geological Society are directed to make it known to the Public, that the Authors alone are responsible for the facts and opinions contained in their respective papers.

It is requested that all letters and communications to the Secretaries, and presents to the Society, may be addressed to the House of the Geological Society, No. 20, Bedford Street, Covent Garden, London.

OFFICERS AND COUNCIL OF THE GEOLOGICAL SOCIETY OF LONDON.

1827.

PRESIDENT.

WILLIAM HENRY FITTON, M.D. F.R.S.

VICE-PRESIDENTS.

ARTHUR AIKIN, Esq. F.L.S.
JOHN BOSTOCK, M.D. F.R.S. L.S. & H.S.
Rev. WILLIAM DANIEL CONYBEARE, F.R.S.
Rev. ADAM SEDGWICK, F.R.S. Woodwardian Professor, Cambridge.

SECRETARIES.

WILLIAM JOHN BRODERIP, Esq. F.L.& H.S. | RODERICK IMPEY MURCHISON, Esq. F.R.S.

FOREIGN SECRETARY.

HENRY HEULAND, Esq.

TREASURER.

JOHN TAYLOR, Esq. F.R.S.

COUNCIL.

HENRY THOMAS DE LA BECHE, Esq. F.R.S.
J. E. BICHENO, Esq. Sec. L.S.
DAVIES GILBERT, Esq. M.P. V.P.R.S.
GEORGE BELLAS GREENOUGH, Esq. F.R.S.
JOHN FREDERICK WILLIAM HERSCHEL, Esq. Sec. R.S.
ARMAND LÉVY, Esq.
CHARLES LYELL, Esq. F.R.S. & L.S.
WILLIAM HASLEDINE PEPYS, Esq. F.R.S. L.S. & H.S.
Rev. JOHN HONEYWOOD RANDOLPH.
CHARLES STOKES, Esq. F.R.S. S.A. & L.S.
J. F. VANDERCOM, Esq.
HENRY WARBURTON, Esq. M.P. F.R.S.
THOMAS WEBSTER, Esq.
THOMAS YOUNG, Esq.

ADVERTISEMENT.

THE Editors of the Transactions of the Geological Society are directed to make it known to the Public, that the Authors alone are responsible for the facts and opinions contained in their respective papers.

It is requested that all letters and communications to the Secretaries, and presents to the Society, may be addressed to the House of the Geological Society, No. 20, Bedford Street, Covent Garden, London.

OFFICERS AND COUNCIL OF THE GEOLOGICAL SOCIETY OF LONDON.

1828.

PRESIDENT.

WILLIAM HENRY FITTON, M.D. F.R. & L.S.

VICE-PRESIDENTS.

ARTHUR AIKIN, Esq. F.L.S.

Rev. WILLIAM BUCKLAND, D.D. F.R. & L.S. &c. Professor of Mineralogy and Geology in the University of Oxford.

CHARLES LYELL, Esq. F.R. & L.S.

Rev. ADAM SEDGWICK, F.R.S. Woodwardian Professor in the University of Cambridge.

SECRETARIES.

WILLIAM JOHN BRODERIP, Esq. F.R. & L.S.

HENRY BURTON, M.D.

FOREIGN SECRETARY.

RODERICK IMPEY MURCHISON, Esq. F.R. & L.S.

TREASURER.

JOHN TAYLOR, Esq. F.R.S.

COUNCIL.

JAMES EBENEZER BICHENO, Esq. F.R.S. Sec. L.S.

JOHN BOSTOCK, M.D. F.R. & L.S.

Rev. WILLIAM DANIEL CONYBEARE, F.R.S.

JOHN CRAWFURD, Esq. F.R.S.

MICHAEL FARADAY, Esq. F.R.S.

DAVIES GILBERT, Esq. M.P. Pres. R.S. F.L.S. &c.

GEORGE BELLAS GREENOUGH, Esq. F.R. & L.S.

JOHN FREDERICK WILLIAM HERSCHEL, Esq. V.P.R.S. Pres. Astron. Soc.

HENRY HEULAND, Esq.

LEONARD HORNER, Esq. F.R.S.

Rev. JOHN HONEYWOOD RANDOLPH, M.A.

NICHOLAS AYLWARD VIGORS, Esq. F.R. & L.S. Sec. Z.S.

Sir RICHARD RAWLINSON VYVYAN, Bart. M.P. F.R.S.

HENRY WARBURTON, Esq. M.P. F.R.S.

ADVERTISEMENT.

THE Editors of the Transactions of the Geological Society are directed to make it known to the Public, that the Authors alone are responsible for the facts and opinions contained in their respective papers.

It is requested that all letters and communications to the Secretaries, and presents to the Society, may be addressed to the Apartments of the Geological Society, Somerset House, London.

CONTENTS.

PART I.

I. *On the Geology of Southern Pembrokeshire. By* H. T. De la Beche, *Esq. F.G.S. F.R.S. F.L.S. &c.* . . . . . p. 1

II. *On the Lias of the Coast, in the Vicinity of Lyme Regis, Dorset. By* H. T. De la Beche, *Esq. F.G.S. F.R.S. F.L.S. &c.* . . p. 21

III. *Observations on the Strata at Hastings in Sussex. By* Thomas Webster, *Esq., Secretary to the Geological Society.* . . . p. 31

IV. *Observations on the Purbeck and Portland Beds. By* Thomas Webster, *Esq., Secretary to the Geological Society.* . . . p. 37

V. *Observations on Belemnites. By Mr.* J. S. Miller, *A.L.S. &c. Communicated by the Rev.* W. D. Conybeare, *F.G.S. F.R.S. &c.* . p. 45

VI. *Observations on the Genus Actinocamax. By Mr.* J. S. Miller, *A.L.S. &c.* . . . . . p. 63

VII. *On the Geology of Rio de Janeiro. By* Alexander Caldcleugh, *Esq. F.G.S.* . . . . . p. 69

VIII. *On a recent Formation of Freshwater Limestone in Forfarshire, and on some recent Deposits of Freshwater Marl; with a Comparison of recent with ancient Freshwater Formations; and an Appendix on the Gyrogonite or Seed-vessel of the Chara. By* Charles Lyell, *Esq. F.G.S. F.R.S. F.L.S. &c.* . . . . . p. 73

IX. *Geological Sketch of the North-western Extremity of Sussex, and the adjoining Parts of Hants and Surrey. By* Roderick Impey Murchison, *Esq. Sec. G.S., F.R.S. &c. &c.* . . . . . p. 97

X. *On the Chalk and Sands beneath it (usually termed Green-sand) in the Vicinity of Lyme Regis, Dorset, and Beer, Devon. By* H. T. De la Beche, *Esq., F.G.S. F.R.S. F.L.S. &c.* . . . . . p. 109

XI. *On the Formation of the Valley of Kingsclere and other Valleys, by the Elevation of the Strata that inclose them; and on the Evidences of the original Continuity of the Basins of London and Hampshire. By the Rev.* W. Buckland, *S.T.P. F.R.S. F.L.S. President of the Geological Society, and Professor of Mineralogy and Geology in the University of Oxford, &c.* . . . . . p. 119

XII. *Notices and Extracts from the Minute-Book of the Geological Society.* . . . . . p. 131 to 141

1. *On the Iron-Sand Formation of Sussex. By* Gideon Mantell, *Esq. F.G.S. F.R.S. F.L.S. &c. In a Letter to Dr.* Fitton, *Secretary to the Geological Society.* . . . . . p. 131

2. *Section of a Well sunk at Streatham Common, in the County of Surrey. By Mr.* Thomas Yeats. *In a Letter addressed to* —— Brown, *Esq. Secretary to the Westminster Fire-Office; and by him communicated to the Geological Society.* . . . . . p. 135

3. *Notice respecting the Quartz-rock of Bromsgrove Lickie. By Mr.* James Yates, *F.G.S.* . . . . . p. 137

4. *Notice respecting the Pebbles in the Bed of Clay which covers the new Red Sandstone in the S.W. of Lancashire. By Dr.* Bostock. p. 138

5. *Extract of a Letter from* Alexander Gordon, *Esq. to* D. Gordon, *Esq., of Abergeldie, describing three successive Forests of Fir embedded in a Peat Moss;—accompanied by Specimens.* . . p. 140

6. *Notice on Carbonate of Copper, occurring in the Magnesian Limestone, at Newton Kyme, near Tadcaster. By* W. Marshall, *Esq. F.G.S.* . . . . . p. 140

PART II.

XIII. *Remarks on the Geology of Jamaica. By* H. T. De la Beche, *Esq. F.G.S. F.R.S. F.L.S.* . . . . . p. 143

XIV. *Notice on the Geology of the Ponza Isles. By* G. Poulett Scrope, *Esq. F.G.S. F.R.S. &c.* . . . . . p. 195

XV. *Observations on the Structure of the Border Country of Salop and North Wales; and of some detached Groups of Transition Rocks in the Midland Counties. By the Rev.* James Yates, *M.A., F.G.S.* . p. 237

XVI. *Remarks on some Parts of the Taunus and other Mountains of the Dutchy of Nassau;—in Explanation of Specimens presented to the Geological Society of London. By Sir* Alexander Crichton, *M.D. Knt. G.S.W. F.R.S. &c.* . . . . . p. 265

XVII. *Notes on the Geological Structure of Cader Idris. By* Arthur Aikin, *Esq. F.G.S. &c.* . . . . . p. 273

XVIII. *On the Strata of the Plastic Clay Formation exhibited in the Cliffs between Christchurch Head, Hampshire, and Studland Bay, Dorsetshire. By* Charles Lyell, *Esq., F.G.S. F.R.S. F.L.S.* . . p. 279

XIX. *On the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire. By* Charles Lyell, *Esq. F.G.S. F.R.S. F.R.S.* p. 287

XX. *On the Coal-field of Brora in Sutherlandshire, and some other Stratified Deposits in the North of Scotland. By* Roderick Impey Murchison, *Esq. Sec. G.S., F.R.S. &c. &c.* . . . . . p. 293

XXI. *Notices and Extracts from the Minute-Book of the Geological Society.* . . . . . p. 327 to 335

1. *Notice respecting the Appearance of Fossil Timber on the Norfolk Coast. By* Richard C. Taylor, *Esq. F.G.S.* . . . . . p. 327

2. *Description of a peculiar Species of Granite. In a Letter from Earl* Compton *to the Rev. Dr.* Buckland, *F.G.S. F.R.S. F.L.S.* . p. 329

3. *Translation of a Letter from* M. de Gimbernat, *of Geneva, to* G. B. Greenough, *Esq. F.G.S. F.R.S. F.L.S.* . . . . p. 331

4. *Extract of a Letter from* B. de Basterot, *Esq. to Dr.* Fitton, *V.P.G.S. F.R.S. &c.* . . . . . p. 334

PART III.

XXII. *On the Volcanic District of Naples. By* G. Poulett Scrope, *Esq. F.G.S. F.R.S. &c.* . . . . . p. 337

XXIII. *Supplementary Remarks on the Strata of the Oolitic Series, and the Rocks associated with them, in the Counties of Sutherland and Ross, and in the Hebrides. By* Roderick Impey Murchison, *Esq. Sec. G.S., F.R.S. F.L.S.* . . . . . p. 353

XXIV. *On the Fossil Remains of two New Species of Mastodon, and of other Vertebrated Animals, found on the left Bank of the Irawadi. By* William Clift, *Esq. F.G.S. F.R.S. &c.* . . . . . p. 369

XXV. *Geological Account of a Series of Animal and Vegetable Remains and of Rocks, collected by J. Crawfurd, Esq. on a Voyage up the Irawadi to Ava, in* 1826 *and* 1827. *By the Rev.* William Buckland, *D.D. F.G.S. F.R.S. F.L.S.* . . . . . p. 377

XXVI. *Description of Fossil Remains of some Animals from the North-East Border of Bengal. By* J. B. Pentland, *Esq.* . . . . . p. 393

XXVII. *On the Cycadeoideæ, a Family of Fossil Plants, found in the Oolite Quarries of the Isle of Portland. By the Rev.* William Buckland, *D.D. F.G.S. F.R.S. F.L.S.* . . . . . p. 395

Supplementary Remarks on the supposed Power of the Waters of the Irawadi to convert Wood to Stone. By the Rev. W. Buckland, *D.D. V.P.G.S. F.R.S. F.L.S.* . . . . . p. 403

XXVIII. *Notices and Extracts from the Minute-Book of the Geological Society* . . . . . p. 405 to 406

1. *Additional Remarks on the Nature and Character of the Limestone and Slate, principally composing the Rocks and Hills round Plymouth. By the Rev.* Richard Hennah, *F.G.S.* . . . p. 405

2. *Notice respecting a Whin-dyke in the Cooper Colliery, near Blythe, Northumberland; drawn up from the information of* Mr. Bryham, *Agent at the Cooper Coal Works, by* W. C. Trevelyan, *Esq. F.G.S. &c.* . . . . . p. 405

3. *Extract of a Letter from* Charles Stokes, *Esq. F.G.S. F.R.S. &c. to* William John Broderip, *Esq. Sec. G.S., F.R.S. &c.; explanatory of three Drawings of Echini.* . . . . . p. 406

Index . . . . . p. 407

A List of Donations to the Library, to the Collection of Maps, Plans, Sections and Models; and to the Museums. . . . . . p. 423

Explanation of the Plates.

The Binder is directed to place the three Tables of Officers and Council immediately after the Title Page, and in the order in which they were published.

CORRIGENDA ET ADDENDA.

In the explanation of Plate XXXIII, fig. 2, *for* "Pleurobronchus" *read* "Pleurobranchus;" and *for* "Heninghaus" *read* "Hoeninghaus."

Dr. Buckland has furnished the following:—

Page 396, line 3. I think it proper to notice that the internal structure of the recent Cycadeæ here alluded to, as well as that of their fossil analogues, the Cycadeoideæ, was pointed out to me by Mr. Brown in the spring of 1828.

Page 397, line 23. The expression "these differences," inasmuch as several characters are enumerated in the preceding paragraph equally belonging to Cycadeæ and to the fossils, is not quite correct: for the external position and greater breadth of the laminated circles alone determined Mr. Brown to consider the fossils as belonging to a family probably distinct from Cycadeæ.

Page 397, line 5, *for* revoluta *read* circinalis.

Page 399, line 20, *for*—"they, however, exhibit no traces of vessels such as radiate from the centre and form the silver grain in more perfect kinds of wood," *read*—"they, however, differ in the want of medullary rays which so generally exist in dicotyledonous wood."

I.—*On the Geology of Southern Pembrokeshire.*

By H. T. De la BECHE, Esq. F.R., L. and G.S.S. etc.*

[Read May 16th 1823.]

THE district which forms the subject of the present memoir, comprehends the whole of Southern Pembrokeshire. It deserves the attention of the geologist, not only from its including the western extremity of the great coal-basin of South Wales, and exhibiting along the boundaries of that basin, within a narrow compass, the mutual and diversified relations of the carboniferous and transition systems of rocks; but also from its presenting in both those systems striking instances of disturbance and contortion, and displaying perhaps in a more remarkable manner than any other district in England the real character of those varieties of trap which so commonly occur associated with transition formations†. The long series of natural sections presented

* The author begs to state from what sources he has derived any important information on the subject of the present memoir.—A valuable paper by Dr. Kidd, giving the results of his observations on the trap-rocks near St. David's, made during a journey in the year 1813, was published in the second volume of the first series of the Geological Transactions, in the year 1814. In that paper will be found the most accurate account then made public of the greenstone-rocks associated with transition formations. The Rev. W. D. Conybeare, who had been the companion of Dr. Kidd on the journey above referred to, again visited the district in the year 1816, and on this occasion succeeded in ascertaining the general structure of the district; but the tempestuous state of the weather having prevented him from examining the coast, the most decisive evidence was yet wanting to prove the accuracy of his conclusions. The want experienced by Mr. Conybeare of any thing deserving the name of a map has since been completely remedied by the publication of the Ordnance map of Pembrokeshire: it is scarcely possible to appretiate too highly the assistance which this and the other parts of that splendid survey of England are calculated to afford to the geologist. Availing himself of all this information, and particularly of the notes and advice of his friend Mr. Conybeare, in the summer of 1822 the author visited every part of the district, and more particularly directed his attention to the sections presented by the coast. He has drawn up the present memoir from the notes made by him on that excursion.

† The district derives additional interest from the close resemblance it bears, in geological structure, to the Isle of Anglesea, at the opposite extremity of the coast of Wales.—See Mr. Henslow's paper in the Transactions of the Cambridge Philosophical Society, vol. i. page 359.

by the tortuous coast which extends from St. Bride's Bay on the west to Caermarthen Bay on the east, and by the shores of Milford Haven which traverses the centre of the district, afford remarkable facilities for investigating the structure of the country.

The surface of the district, in general, is exceedingly undulated: few of the ranges, however, are striking, nor are there any of very considerable height. The country near the shores of Milford Haven is often well wooded; but in other parts it is almost bare of timber, and particularly to the north-west of Haverfordwest.

Of the formations occurring within the district I shall treat in the following order:

1. Trap*.
2. Greywacké.
3. Old red Sandstone.
4. Carboniferous, or Mountain Limestone.
5. Coal-measures.

§ 1.—Trap.

The rocks which I mean to comprehend under this name, are very abundant in the district. They form in several cases insulated hills, and occasionally continuous ridges of some extent. Their appearance on the surface is usually distinguished by craggy piles of rock, such as in Devonshire are called *Tors*, but in Pembrokeshire and other parts of Wales are termed *Carns*. The best characterized varieties of trap consist of distinctly crystallized aggregates of felspar, quartz, and hornblende, forming syenite or greenstone, according as the first or last of these ingredients predominates. The former rock is of much rarer occurrence than the latter. Augite has not hitherto been discovered in these coarsely crystallized aggregates.

* I have placed the trap at the head of the formations of the district, not as being invariably the lowest in the order of position, nor as being for that reason regarded by me as the most ancient; but because it is liable to occur in any part whatever of the series, and therefore is frequently found to occupy the lowest place. In the sequel I shall have occasion to notice many appearances which strongly favour the notion that the trap has been forcibly intruded amongst the other rocks at a period subsequent to their consolidation. In applying therefore, in the course of the present memoir, the expressions "strata," "stratified," &c. to trap, it is by no means my intention to discountenance the notion above alluded to, much less to signify my adoption of any other in opposition to the former. I only mean to imply by these expressions, that there is a parallelism of texture in the trap, which it has in common with a contiguous rock belonging to some other formation; and that this texture is also parallel to the common surface of separation between the trap and that other rock.

Associated with these aggregates are other rocks of a more obscure character, yet so connected with the former, as clearly to be referrible to the same formation. Of their real constitution, unfortunately, neither mineralogical character nor chemical analysis affords any decisive evidence. They present a fine-grained homogeneous paste, which often becomes porphyritic from crystals of felspar, and more rarely of hornblende, imbedded in it: they occasionally contain epidote, and perhaps also chlorite. I am inclined to consider them as fine-grained aggregates of the three minerals so evidently displayed in the above-mentioned crystalline varieties of trap, and to attribute to the different proportions of these ingredients the subordinate shades of character by which these rocks are diversified. Where the felspar may be supposed to prevail, the result approaches to compact felspar*; where the quartz, we have a regular hornstone, generally coloured, however, by minute green particles disseminated through it, which probably consist of hornblende. The fine-grained variety with an excess of hornblende has not hitherto been discovered in the district. To certain of this family, in which hornblende predominates, the French have given the name of *Aphanite;* but they would denote these fine-grained rocks, generically, by the term *pierre cornéenne,* which so well expresses their usual aspect. I shall naturalize, on this occasion, the term *Cornean,* and shall apply to it the epithet Felspathic, or Quartzose, according to the ingredient supposed to prevail in the rock.

Besides the above-mentioned varieties of trap, there occurs one which has the appearance of a conglomerate. The base is a black and very compact trap, which contains grains of quartz, and seeming fragments of crystallized felspar and of compact felspathic cornean. It is probably, however, a pseudo-conglomerate, or concretional rock, originating in a peculiar and cotemporaneous aggregation of its constituent parts†.

* On felspar, as a constituent of similar rocks, see Dr. Macculloch on the Classification of Rocks. pp. 480, 481.

† Trap-rocks, generically similar to those of Southern Pembrokeshire, are common to almost all transition-districts. Thus in the northern part of the county, trap forms the entire collateral chain to the north of the great range of Prescilly, and reappears on the line of the same chain in many insulated points on either side of Fishguard. On the western side of Fishguard Bay greenstone is found resting upon quartzose cornean; and the insulated summits of a hill, remarkable for having formed the camp of a French invading division, consist of greenstone. To cornean, as I believe from the inspection of specimens, belong the rocks in Snowdonia, described as stea-schist by Messrs. Woods and Phillips (see Annals of Philosophy for Nov. and Dec. 1822); genuine stea-schist being in my opinion essentially connected with talcose slate, of which Snowdonia presents no traces. Cader-Idris, and the range of the Arans and Aranigs, belong unquestionably to a trap-formation; as do the Wrekin and Caer-Caradoc in Shropshire, and the hills in the neighbour-

I shall now proceed to describe the various insulated masses, belonging to varieties of trap, that occur within the district.

Vicinity of St. David's.

Penberry Rock, to the north of St. David's, is of an irregular conical shape. Its summit is a greenstone, composed of well-defined grains of hornblende and felspar, of middling size. Felspathic cornean is in some parts associated with the greenstone. Greywacké forms the base of the hill, and appears to rest upon the trap. On the northern side however, in several places, trap is intermixed with greywacké, and in some is interstratified with it. In one instance a continuous mass of trap descends from the top of the hill to the sea. It seems rather to be interposed between the strata of greywacké, than to cut through them.

At a little distance to the south-west of Penberry a ridge of trap emerges, which forms a remarkable feature in the country; and after reaching its highest point at a rock called Llacithty, extends to the sea in Whitesand Bay. It is composed of the same kind of massive unstratified greenstone as Penberry Rock, of which it may be deemed the continuation.

Greywacké is observable in small quantity to the north of the ridge of Llacithty, between Porthyrow and a bay near Cesselvawr Head. It is much intermixed with trap; so that it is difficult to determine whether the latter be transverse or conformable to the strata of greywacké. Greywacké forms the north-western base of the ridge of Llacithty; but further to the north-west another ridge of greenstone appears, extending from Cesselvawr Head to St. David's Head. In substance it resembles the rock of Llacithty, excepting that it is stratified, with a dip to the north-west of about 45°.

A series of rocky tors, to the west and south-west of St. David's, marks the course of a large body of trap, extending from Crosswoodig on the north, to Pen-y-Main-Melin Point on the south. This mass has not the slightest appearance of being stratified. It is very variable in its composition. Near St. David's felspathic cornean forms its base, in which are disseminated numerous crystals of quartz and felspar. At Trevaythan the base is more earthy, and contains

---

hood of Builth. Greenstone and porphyritic cornean occur extensively in Cumberland. To the trap-formation belong the insulated ridges of Malvern and Charnwood forest. Of the same æra is the greenstone surrounding Dartmoor, and occurring in other parts of Devonshire, as also in Cornwall. The porphyritic elvans of those counties, though agreeing with some varieties of cornean in having for their basis a paste of compact felspar, or perhaps of claystone, appear rather to belong to a more ancient formation than the trap.

crystals of a green colour, crystallized felspar, and very little quartz. At the tor of Clegurfwya, and at other points to the west of St. David's, the rock resembles that of Treginnis, described by Dr. Kidd (see Geological Transactions, first series, vol. ii. p. 89.) as "assuming the appearance of compact earthy felspar, being of an olive-green colour, and probably containing epidote." A section of this body of trap extends along the coast from the point opposite the Horse Rock in Ramsey Sound, to Pen-y-Main-Melin Point, and thence to the point opposite the rocks called the Bishops and the Crow.

The two irregularly conical hills called the Beacons of Ramsey, the one on the northern, the other on the southern side of the island, are composed of trap. The northern beacon consists principally of greenstone, resembling that of the ridge of Llacithty. On the west it is bounded by the sea, but on every other side by strata of greywacké. A bed or dyke of cornean occurs between the vertical beds of greywacké that separate the two beacons, having, like those beds, a direction from east to west. The southern beacon, together with Margery Isle, and so much of Ramsey Island as lies to the south of a line drawn from near the House to the southern end of Abermawr Sand, consists chiefly of porphyry. Felspathic and quartzose cornean are associated with the trap on this side of the island. A substance resembling anthracite is found in vertical veins traversing the trap of the southern part of the island. Wherever it is exposed to the sea, it is washed out, and the walls of trap are left standing, forming picturesque coves.

It would be difficult to determine accurately, owing to the want of natural sections, how much of the surface immediately around St. David's consists of trap. Blocks of it, belonging principally to the greenstone variety, lie scattered over the soil in every direction, and are often seen resting upon greywacké. At Clegir Bridge, near St. David's, quartzose cornean, occasionally striped, is found associated with greenstone. Following the high-road from thence to Solfach, almost all the field-divisions are found to consist of blocks of trap. Some few, of large dimensions, which have not been thus appropriated, are observed resting on greywacké, which is here the prevailing rock. Trap occurs intermixed with greywacké in the neighbourhood of Solfach. It is found in ascending the hill on the road to Haverfordwest. Porphyritic greenstone is met with under Upper Solfach. Both the points of Solfach Harbour are composed of greenstone, which may be traced across two or three small headlands to the eastward, there forming a vertical bed or dyke not more than a few yards in thickness, having the same direction as the vertical beds of greywacké, and probably interposed between them. Pursuing the high-road from Solfach to Newgate Bridge, the blocks in the field-divi-

sions are found to consist of trap, and principally of greenstone. These blocks become less abundant as you approach the cliff.

Range from Roche to Trafgarn.

A chain of hills, considerably elevated above the surrounding country, extends from Cuffern Mountain to Trafgarn Rocks, most of the highest points in the chain being crowned with rocky tors. The most conspicuous of these tors are those of Trafgarn. The less elevated and apparently insulated tor, upon which Roche Castle stands, is connected towards the east with Cuffern Mountain : towards the west, the same mass of rock extends to the distance of about half a mile on the road to Bathesland. Nearly all these tors are of the same kind of quartzose cornean ; in which, however, the proportion of quartz varies, the rock of Roche containing the most. This cornean has no appearance of stratification. Other varieties of trap, however, are associated with the cornean in this range. Blocks of porphyritic greenstone occur at Trafgarn ; and blocks of greenstone and of black porphyritic cornean are found between Roche and Cuffern Mountain.

This chain is bounded to the north and south by greywacké, through which it appears to be protruded. At its western extremity, near Bathesland, it is covered by coal-measures, over which, at many places in that neighbourhood, are strown blocks of quartzose cornean and greenstone.

Trap between Druson Haven and Broad Haven.

A tract between these two havens, consisting of coal-measures and greywacké, and extending about two miles from north to south and about half a mile from east to west, is bestrown with blocks of trap, of which many must weigh from five to six tons. They consist principally of greenstone and greenstone-porphyry. The only spot in the neighbourhood where trap appears *in situ*, is at the hill behind Druson Haven, where the two branches of a rivulet (the one descending from Nolton, the other from Druson) unite. The prevailing rock at this hill is greenstone, and it seems to project through the other rocks. Near the trap the greywacké is contorted. (See Pl. II. fig. 1.)

Trap of Gouldtrop Road in St. Bride's Bay.

From Gouldtrop Road to Millhaven there is a fine and interesting section of the trap and of the other rocks here connected with it. (See Pl. II. fig. 2.) The rock at Gouldtrop Road is either a syenite or a large-grained greenstone, according as quartz is present or wanting in the mass. Gouldtrop Head is formed of a smaller-grained greenstone. The same rock appears also well

characterized near Millhaven; and it is indeed the prevailing variety of trap in the tract under consideration.

By reference to the plate it will be seen that the body of trap rises at Millhaven from beneath old red sandstone, which is disturbed and bent near the place of contact; that at the base of the cliff near Gouldtrop Head it rests on a curved mass of carboniferous limestone; and that at Gouldtrop Road it abuts against, and rests upon, not only the limestone, but also coal-measures, of which the strata are bent back. Here then is a mass of trap, not differing in mineralogical character from those masses of the same rock which have previously been described as associated with and subjacent to greywacké, and which by many would be termed, from those circumstances of position, *transition* trap. Yet here we find it, at the same time supporting old red sandstone, and incumbent on carboniferous limestone and on coal-measures. It would be difficult to explain these phænomena by any other hypothesis than that of the forcible intrusion of trap among the other rocks, at a period subsequent to that of their being formed and consolidated.

Range of Trap from Bolton Beacon to Benton Castle.

This mass appears to be connected with the former by a dyke which passes through Rosepool and Walwin's Castle to Tiers Cross; since blocks of trap can be traced along this line, and since a perpendicular dyke of felspathic cornean, a few feet thick, occurs in the face of the cliff at Walwin's Castle. The blocks are far from numerous, and are rather difficult to trace. They mostly consist of greenstone, like that near the parsonage at Walwin's Castle: some however approach in character to cornean.

From Bolton Beacon eastward, this range is considerably elevated above the neighbouring country, but mostly so towards its two extremities. It varies in substance in different parts of its course. At Bolton Beacon it is a greenstone, approaching in some places to greenstone-porphyry: from Johnston to Trooper's End syenite predominates; which sometimes, owing to the absence of quartz, becomes a large-grained greenstone. Felspathic cornean occurs near Thurston; and the same rock prevails at the eastern extremity near Benton Castle, where it forms several small tors on the surface.

This range is bounded on the north, from Tiers Cross to Nash, by coal-measures, except near Johnston, where a small band of mountain limestone intervenes. Both the coal-measures and the limestone between Tiers Cross and Nash, are highly contorted. From Nash to Milford Haven the range is flanked on the north by a rock resembling greywacké (to be described in the sequel), which towards Guilford has its strata nearly vertical. The same rock

forms the entire southern boundary of the trap, and is every where found to dip from it.

Trap of Marloes and Skomer Island.

This mass of trap, which forms the southern point of St. Bride's Bay, is separated from that of Millhaven by well characterized old red sandstone, and is bounded on the south by the rock resembling greywacké. It forms a wedge-shaped mass, which gradually becomes narrower towards the east, and does not extend inland above half a mile eastward of Marloes. It appears to rest upon the sandstone, and to rise from beneath the rock resembling greywacké. Both these rocks dip at a considerable angle to the south; and as the breadth of the trap diminishes, they gradually approach one another, until they unite to the east of Marloes.

This mass consists principally of greenstone, containing rocks, however, intermediate between cornean and greenstone. Between St. Martin's Haven and Marloes there is a small tor of trap. At a small cove near Mosely Wick Farm, where the trap comes in contact with the old red sandstone, a coarse-grained siliceous rock appears to proceed from the trap in veins, which diminish as they recede from it, and penetrate to a short distance between the strata of sandstone.

All the north of Skomer Island consists of massive trap, having the character principally of fine-grained compact greenstone, and sometimes approaching to cornean. The small peninsula, however, to the east of the landing-place, must be excepted, where some stratified rocks of ambiguous appearance occur. The southern part of the island consists of stratified greenstone, dipping at about 48° to the south-east. Between this and the greenstone belonging to the north of the island a quartzose cornean, mostly striped, occurs. In some parts of the island hornblende is the prevailing ingredient of the rock.

From the information of intelligent seamen it should appear that Grasholm Island, and the rock on which the Smalls Lighthouse stands, consist of a rock similar to that of the northern side of Skomer Island. If this account be correct, a great dyke of trap must extend westward from Marloes to the Smalls Lighthouse, parts of which only appear above the water. The bottom of the sea along that line is known to be very rocky.

§ 2.—Greywacké.

(A) *Great Greywacké District, North of the Coal-basin.*

The great tract of greywacké, which extends through North Pembrokeshire, has its southern boundary-line within the limits of our district. This

line passes from west to east, beginning in the cliffs of St. Bride's Bay, a little to the north of Broad Haven, and leaving our district at Lethergloyn, near Narberth. So much of this greywacké-tract as falls within our present scope, may be divided into two portions, that of St. David's, and that of Haverfordwest; the former lying to the north and west, the latter to the south and east of the Cuffern range of trap.

St. David's Greywacké District.

Greywacké, mixed with trap, occurs abundantly from Abercíddy Bay to Penberry Rock, which it nearly surrounds. It is worked for roofing-slate at some rocks which project into the sea near Penberry Crags. From the cliffs under Penberry Rock to Cesselvawr Head it is much intermingled with trap. Perpendicular beds of slaty greywacké, bearing from north-east to south-west, occupy the space between the two trap-ridges of Llacithty and Cesselvawr. To the south of Llacithty Rock, greywacké extends from the Slate-quarry on the northern side of Whitesand Bay to the re-commencement of the trap opposite the Horse Rock, forming in its way the cliffs in the neighbourhood of Pencarnon. At the Slate-quarry the strata are perpendicular, bearing east and west, conformably to the range of Llacithty; from Pencarnon southwards they dip to the west, ranging north and south, conformably to the trap-range which stretches from Crosswoodig. In the immediate neighbourhood of St. David's, from the quantity of trap-blocks on the surface, and the want of natural sections, the greywacké can hardly be traced as distinct from the trap. From St. David's to Newgate Bridge the two rocks are much intermixed; but excepting near Solfach, the cliffs on the northern side of St. Bride's Bay, from about a mile to the west of Porthclaise as far as Newgate Bridge, consist entirely of greywacké, disposed for the most part in thick beds, interstratified with a rock resembling old red sandstone. It is from the latter that the stone for the new work at St. David's cathedral has been quarried. The small bays between Porthclaise and Carbudie Mill, and thence to Trellerwer, afford good sections of this rock; which is also found between Roche Bridge and New Mill. A quartzose conglomerate, resembling one of old red sandstone, occurs between Clegir Bridge and the sea. The general bearing of the greywacké, between St. David's and the Cuffern range of trap, is from east to west, the dip being to the south.

Haverfordwest Greywacké District.

This is bounded on the north by the Cuffern range of trap; on the north-west, from Roche to Druson Haven, by coal-measures: on the south-west,

from Druson Haven to Broad Haven, a section of the greywacké is presented by the coast. On both sides of Druson Haven the strata are much contorted. (See Pl. II. fig. 1.) From thence to Broad Haven there are both thick and slaty beds, though usually in the Haverfordwest district the greywacké is slaty. The southern limits of this district will best be traced on the map. (See Pl. I.) Near the eastern extremity of the southern boundary-line, between Lethergloyn and the river near Canaston, the junction of the greywacké with the superincumbent old red sandstone is tolerably well defined.

(B) *Greywacké South of the Coal-basin.*

On the southern side, and also round the eastern extremity, of the trap-ridge extending from Bolton Beacon to Benton Castle, a peculiar rock occurs, which may be considered as a neutral one, between greywacké and old red sandstone, having more the character of the former than of the latter, though seldom acquiring the slaty appearance of the greywacké occurring to the north of the Coal-basin.

This rock commences in a point near Tiers Cross, and gradually widens towards the west. From Tiers Cross it is bounded on the south by genuine old red sandstone, into which it passes so gradually that no line of separation can be drawn between them. The boundary, however, may be considered as passing through Redstock, and thence southwards of Rosemarket to Llanstadwell. Leaving Johnston for Milford, yellowish-brown beds of sandstone, which may be termed friable greywacké, are met with, dipping from the trap. Loose sandy beds occur not far from Johnston on the road to Rosemarket, and at a little distance from the trap on the road between Rosemarket and Waterless. At a point where a small rivulet crosses the last-mentioned road, beds of greywacké appear dipping to the west. At Milton, between Rosemarket and Pembroke Ferry, a few thin beds are seen dipping to the south-east, at an angle of 45°, which have more the character of old red sandstone than of greywacké. At Burton the rock is principally of a brownish-gray colour; but two or three red strata traverse the garden of the parsonage. The same rock, with a few red strata occurring here and there, continues nearly to Benton Farm. The beds are sometimes of tolerable thickness, sometimes coarsely slaty, and frequently micaceous. The small peninsula between West Lenion and Pembroke Ferry consists of the same rock, as does the entire peninsula of Cosheston. Very few red strata are observable between Cosheston and Lawrenny Ferry. The dip at Cosheston is to the south-east: that on the south side of Lawrenny Ferry is to the east, at an angle of from 20° to 30°. The western part of the Lawrenny peninsula is also of this rock, mixed with some

red-coloured beds: at the village on the eastern side it has much the appearance of slaty old red sandstone. Between Guilford and the trap are brownish-gray beds, having the aspect of greywacké, mixed with others that resemble old red sandstone. At the bottom of Benton Wood these beds are nearly vertical.

Similar rocks to the preceding occur to the south of the trap near Marloes. They consist either of coarse slate, or of beds very variable in thickness. Thick beds of very compact quartzose sandstone are found resting on the trap to the south of St. Martin's Haven, and dipping to the south at from 45° to 50°.

A section drawn southwards, from the trap of Gouldtrop Road at Talbanny to St. Ann's Head, shows that these beds, which so much resemble greywacké, are intimately connected with old red sandstone. The dip of all the beds in this section is to the south, generally at a high angle. From Talbanny to Mallock Mill we have genuine old red sandstone. At the latter place appear some beds resembling greywacké. To these succeed others of old red sandstone. Near Marloes the pseudo-greywacké recurs, and continues to the coast opposite Gateholm Island. The coast and the island are of old red sandstone. Similar alternations are seen in the cliffs between Little Marloes and St. Ann's Head.

§ 3.—Old Red Sandstone.

The old red sandstone of Pembrokeshire, like the greywacké, may be considered as forming two principal districts; the first lying to the north, the second to the south, of the Coal-basin.

(A) *Old Red Sandstone to the North of the Coal-basin.*

This district, forming the western extremity of that connected tract of old red sandstone which traverses the counties of Hereford, Brecknock, and Glamorgan, lies eastward of that branch of Milford Haven which reaches up to Canaston Bridge, and receives the Cledden or East Cledder river. From Mynwer its southern boundary passes nearly due east, by Templeton and Pendine, to Caermarthen Bay. Its junction on the north with greywacké, between Canaston and Lethergloyn, has been already noticed.

This sandstone along its southern boundary dips to the south, at an angle of from 20° to 25°; but to the north of this boundary the angle increases considerably.

(B) *Old Red Sandstone to the South of the Coal-basin.*

This southern district is subdivided into three minor ones; that of Milford,

that of Pembroke, and that of Orielton : the first lying to the north of Milford Haven, the two latter commencing on the opposite shore, and being separated from one another by a trough of carboniferous limestone.

Milford Subdivision.

The coast of St. Bride's Bay, from the trap of Millhaven to that of Marloes, affords a section of the western part of this subdivision. This sandstone is bounded on the north, from Millhaven to Tiers Cross, by a mass or dyke of trap; and on the north-east, from Tiers Cross to Llanstadwell, by the rock resembling greywacké. On the south, from St. Ann's Head to Llanstadwell, it is terminated by Milford Haven. Skokham Island is a continuation westward of the sandstone which extends from Dale to St. Ann's Head.

The principal dip of the sandstone-beds in this subdivision is to the south. At their junction with the trap, near Millhaven, they are contorted. (See Pl. II. fig. 2.) From thence to St. Bride's they gradually acquire a gentle dip to the south, of from 15° to 20°. At their junction with the trap, near Moselywick, they are highly inclined; which is mostly the case, indeed, with the beds in this subdivision.

In different places the strata vary very much as to hardness. They are sometimes marly, and in other cases they consist of a very compact siliceous grit.

To this subdivision it will be most convenient to refer the beds upon which the coal-measures rest near Langum, at the north-east corner of the range of trap extending from Bolton Beacon to Benton Castle. They have the character rather of old red sandstone than of greywacké, though a few strata resembling the latter are mixed with them. The same beds cross the point near Langum Ferry, and reappear in the eastern part of Lawrenny.

Pembroke Subdivision.

The principal part of this subdivision is contained in a narrow band of sandstone running nearly due east from Milford Haven to Caermarthen Bay, and dipping on either side beneath carboniferous limestone. The Ridgeway, on the road from Pembroke to Penally, commanding fine views of the surrounding country, is the highest hill in this subdivision. The sandstone of this band appears again to the west in two small peninsulas on the southern side of Milford Haven.

The sandstone here treated of closely resembles that of the Milford subdivision; but some near Patterchurch approaches in character to the rock resembling greywacké. A small-grained compact quartzose conglomerate appears in the neighbourhood of Penally. There occurs in several places on the top

of the Ridgeway a loose conglomerate, consisting of rounded pieces of sandstone cemented together by soft red marl. This is particularly observable on the road near the top of the hill above Holloways, between Penally and Tenby.

The dip of the sandstone, in the westernmost of the two above-mentioned peninsulas, at the cliffs north of the Angle Valley, is to the south, at an angle of from 70° to 80° : at the Cliffs near Patterchurch, in the same direction, at about 40° ; and at East Pennar, near Pembroke, it is also to the south, at an angle of about 80°. Owing to the want of natural sections, it is difficult to determine the dip in the Ridgeway. To judge from the edges of a few beds by the road-side between the Ridgeway and Carew, the strata are nearly vertical. On the top of the hill above Penally, a few beds project above the soil, dipping at about 40° to the northward; but the eastern extremity of the Ridgeway is almost wholly concealed by the sands of Penally Burrows.

Orielton Subdivision.

This subdivision, like that of Pembroke, consists of a band of old red sandstone running from west to east, and dipping on either side beneath carboniferous limestone. For its precise limits I must beg to refer to the map. Quartzose conglomerates are observed about Dry Burrows, near Orielton, and between Lambeth and Lambeth Mill.

At the westernmost point of this band of sandstone, in the cliff to the south of West Angle, the strata dip to the north at from 70° to 80° : at Quaits Mill, near Pembroke, they dip to the north-by-east at nearly the same angle. At the easternmost point of the sandstone, in a small cove between Shrinkle Farm and Old Castle Head, the sandstone is perpendicular, and continues so round that head, and round Manorbeer and Swanslake Bays. The edges of the vertical beds are beautifully displayed at low water in Manorbeer Bay. The southern half of Caldy Island is the continuation of the sandstone of Old Castle Head, and, like that head, has its beds vertical, and some of them of a light greenish-blue colour mixed with those which are red. The direction of all these vertical beds is from west-by-north to east-by-south. To the north of Stackpoole Quay the beds are nearly vertical.

§ 4.—Carboniferous Limestone.

Like the greywacké and the old red sandstone, the limestone may be referred to two principal districts, the one lying to the north, the other to the south of the Coal-basin.

(A) *Northern District of Limestone.*

The first appearance of this limestone on the west is in a quarry near Haverfordwest, at a short distance to the west of Maudlin Bridge; whence a band of it, of inconsiderable breadth, extends to Milling near Picton Castle. From thence to the south of Newton the coal-measures lap over and conceal the limestone. In the quarries near the latter place the limestone reappears, and is thence continued by Templeton to Pendine Cliffs in Caermarthen Bay, forming a range about a quarter of a mile in breadth; except near Pendine, where it is somewhat broader.

From the point where it first appears, as far as Milling, the limestone rests upon greywacké; and from Newton Quarries to Pendine Cliffs upon old red sandstone: in either part it sinks beneath the coal-measures. The limestone in this northern district is not very highly inclined, nor is it disturbed like that to the south of the coal-district. At Templeton the dip is about 25° to the south. At the old quarries, at Eglywslwyd, east of Templeton, the strata are horizontal, but incline towards the south as they approach the coal-measures. On the northern side of Marcroes Mountain, near Pendine, the beds dip at about 30° to the south-south-west, and in Pendine Cliff at the same angle to the south-west.

Pendine is situated half on the limestone, and half on old red sandstone; the lower limestone-shale being observable at the junction of the two rocks opposite Pendine Great House. The limestone beds in Pendine Cliffs vary from a few inches to ten feet in thickness, and contain the remains of Encrini, Productæ, Euomphali, and Spirifers. In the face of the cliff are many caverns, some of which have not been formed by the sea, but simply enlarged by it, in consequence of the water washing out the clay contained in them. At the Green Bridge a brook loses itself in a cavern, which has been traced underground 360 yards, and then terminates in a hole eight yards deep. At the distance of about a mile the brook reappears on the coast between Pendine Cliffs and Marcroes Mountain.

(B) *Limestone South of the Coal-basin.*

This district is subdivided into three distinct bands, which are separated from one another by the intervention of the Pembroke and Orielton districts of old red sandstone.

Tenby Limestone Band.

This band supports the coal-measures from Langum Ferry to Tenby, and rests on the old red sandstone of the Ridgeway from Carew to Holloways. At

Carew the band bifurcates, the western branch passing by Nash to the New Dock-yard at Patterchurch, being bounded on the south by the Pembroke district of old red sandstone, and on the north by the rock of Cosheston Mountain.

The north-western branch extends by the quarries of Carew-Newton to Langum Ferry, being bounded on the south-west from Carew to Lawrenny by a branch of Milford Haven, but at Lawrenny and at Langum Ferry by old red sandstone. From Langum Ferry to Johnston no limestone appears along the boundary of the Coal-basin, this being the line along which trap is protruded, and the coal-measures upon that line being very much disturbed. At Johnston, however, the limestone reappears on the northern side of the hill between the trap and the coal-measures, being very much contorted, and occupying a tract about fifty yards broad, and about three-quarters of a mile in length.

From Johnston eastwards no limestone appears, until we reach the shores of St. Bride's Bay, where, in Gouldtrop Road, two or three beds of that rock, not above twenty feet in thickness, are observed between trap and contorted coal-measures. (See Pl. II. fig. 2.) A continuation, probably, of these beds is seen forced up above the level of the sea, below Gouldtrop Head, at some short distance further to the westward. (See same Plate and figure.)

The stratification of this band of limestone, along its whole line, is very much disturbed. At Tenby, behind the sluice-wall, the limestone beds are thrown quite over, so as to appear to rest upon the coal-measures. On the south side of the small bay, of which Castle Hill forms the northern side, the almost vertical beds have a northern dip. A few thin contorted beds are there interposed between other beds that remain tabular. At St. Catherine's Island, opposite this bay, some beds are vertical; others dip to the south, their cleavages occasioning a deceptive appearance of vertical strata trending north and south. From the cliff under the Paragon to that under the Windmill the beds dip to the south at from 70° to 80°. At Holloways the dip is to the north-east at 30°; at St. Florence, to the east at from 20° to 23°; at Ivy Tower, to the south at from 30° to 40°; and at Carew, to the south-south-east at 45°. The limestone is seen at one place only in the cliffs near Patterchurch, where it has the appearance of resting on the basset-edges of old red sandstone. North of Langum Ferry-house the limestone is so much contorted and intermixed with the coal-measures, that sometimes one formation is uppermost, and sometimes the other.

Pembroke Band of Limestone.

To the south of that of Tenby another band of limestone is found, extend-

ing from West Angle on the west, to Giltar and Lidstip Points on the east. It lies in a trough or hollow formed by the dipping beneath it on either side of the old red sandstone belonging to the Pembroke and Orielton divisions of sandstone.

At West Angle there is an excellent section of the western end of this trough, the beds resting conformably on the sandstone on either side, but being contorted in the intermediate parts. (See Pl. II. fig. 3.) The limestone near Pwlychrocan is almost concealed by diluvium, containing rolled pieces of the sandstone and limestone: it may be seen, however, at Greenhill Farm, Upper Hentland Farm, and Eastlington Mill*. The character of this band of limestone, as occupying a trough, is well displayed at Pembroke, which lies in the middle of the hollow. At a small cliff to the west of Bentlas, near Pembroke, the limestone dips to the north at an angle of 70°, and at the opposite side of the river, near East Pennar Farm, to the south at 80°. At Hodgeston the beds are highly inclined, with a drift from west-north-west to east-south-east. At Rock Farm, to the north of Jamestown, they dip to the south at about 60°. In Manorbeer Bay and at Lidstip Point they are vertical, with a drift from west-by-north to east-by-south. At the cove north of Old Castle Head the vertical limestone abuts against the sandstone. In the lane between Lidstip and Penally, near Druselton Farm, the limestone dips to the south at 45°, and in the cliff behind the same farm to the same point of the compass at 80°.

St. Margaret's Island and the northern half of Caldy Island form the continuation of the limestone of the Pembroke trough. The strata there are nearly vertical.

To the north and south of the limestone of this trough, between the limestone and the old red sandstone, wherever a good section is afforded, the slaty beds of the lower limestone-shale are to be discovered. This is particularly observable in West Angle Cliffs, at Grove and East Pennar Farms, and at a small cove between Shrinkle Farm and Old Castle Head. Wherever the shale is exposed to the sea, small coves are formed, as the shale yields more readily to the action of the waves than the limestone- and sandstone-rocks which bound it. The bottom of the deep indenture in the west side of Caldy Island is formed in the continuation of the slaty beds of the cove to the north of Old Castle Head; and the same beds traverse the island from west to east. They become less calcareous as they approach the old red sandstone.

The remains of Encrini, Corals, Productæ, and Euomphali are found in the limestone of the Pembroke band.

* The stone of the latter place is very apt to fuse into scoriæ in the kiln.

St. Goven's Limestone-band.

This is the southernmost of the three bands belonging to the limestone on the southern side of the coal-basin, and it forms the southern extremity of the Pembroke peninsula. The beds of limestone in this band vary from a few inches to six or seven feet in thickness: they may be seen of the former dimensions at Linney Head, and of the latter at St. Goven's Head. The lower limestone-shale separates the limestone from the old red sandstone, as may be seen in a cove north of Stackpole Quay. Encrinites and Productæ occur in some of the beds of this band of limestone.

The sands extending from Newton Burrows to Linney Farm conceal the junction of the limestone with the old red sandstone. Near Linney Head the strata of limestone are horizontal; at St. Goven's Head they dip gently towards the south. In many parts of the band the strata are greatly disturbed: they are contorted near the Eligug Stack* (see Pl. II. fig. 4.); they are vertical and contorted near Stackpole Quay (see Pl. II. fig. 5.); and at a short distance to the north of the latter place they abut perpendicularly against old red sandstone.

Between Linney and St. Goven's Heads there is some fine picturesque scenery. The coast is indented in a most singular manner. Cauldrons, similar to the far-famed Boilers of Buchan, near Peterhead in Scotland, are found in three or four places. One or two occur near Linney Head; another on the western part of Bullslaughter Bay; and the most celebrated, named Bocheston Meer, to the west of St. Goven's Chapel. When the sea rushes into them during a heavy gale of wind, the noise is heard to a considerable distance. The cliffs are tenanted by multitudes of sea-birds, whose clamour adds much to the wild effect of the scenery.

§ 5.—Coal-measures.

Along the northern boundary of this western extremity of the great South-Welsh coal-basin, the coal-measures rest, from Broadhaven in St. Bride's Bay to the lime-quarries near Maudlin Bridge, upon greywacké: from those quarries to Milling, upon carboniferous limestone: at Slebech, on greywacké: at

* The Eligug Stack is a rock at a short distance from the land, south of Linney and Pennyholt Farms. It is sometimes called Pennyholt Stack; and the name of Eligug Stack is given to the larger of two rocks in Bullslaughter Bay. But the former is the real Eligug Stack of the sailors. It is so named from the sea-bird, *Alca Torda* Linn., called Eligug by the country-people, which frequents this rock and other parts of the adjacent coast in great numbers, from the end of April or beginning of May to the beginning of August.

Mynwer, on old red sandstone: and from Newton Quarries to the cove between Pendine Cliffs and Marcroes Mountain, on carboniferous limestone. The coal-measures are bounded on the south, at Gouldtrop Road in St. Bride's Bay, by a thin stratum of carboniferous limestone, which intervenes between them and the trap: from Rosepool to Walwin's Castle and Tiers Cross, by a narrow dyke of trap, which separates them from old red sandstone: from Tiers Cross to Anneykell and Bolton Farms, by the trap of Bolton Beacon: at Johnston, by carboniferous limestone interposed between them and the trap: at Craneham, Clarisson, and Nash, by trap-rocks: at Langum, by old red sandstone: and from Langum Ferry to Tenby, by carboniferous limestone. Excepting along the eastern portion of their northern boundary, these coal-measures have been greatly disturbed. Their contortions may be seen in St. Bride's Bay at the cliffs extending from the hill north of Broadhaven to Gouldtrop Road, where as they approach the trap they are most curiously twisted (see Pl. II. fig. 2.); and in Caermarthen Bay at the cliffs extending from Tenby to Sandersfoot (see Pl. II. fig. 6.). The most remarkable contortions are at Monk's Stone Point near Tenby, represented in the adjoining figure.

Stone-coal, or culm, is the only variety of coal that occurs in Pembrokeshire, bituminous coal being altogether wanting in the district. The beds of stone-coal usually worked will be seen in the following section of the collieries belonging to I. M. Child, Esq. at Begelly, a village situate nearly midway between the southern and northern boundaries of the basin, on the road from Tenby to Narberth. The dip is to the south-west or south-south-west, at about one in three.

Section at Begelly Collieries, from the Surface downwards.

Miner's Names.		Thickness. Ft. In.
Rock	Siliceous grit	variable according to the situation of the pit.
Upper or *Rock Vein*	*Stone-coal*	3 6
Dunstone	Shale	9 0
Binder	Shale	9 0
Rock	Siliceous grit	3 6
Slate	Slaty shale, with abundance of ironstone nodules	6 0
Low Vein	*Stone-coal*	from 1ft. 6in. to 1 10
Dunstone	Shale	7 0
Slate	Slaty shale	12 0
Rock	Siliceous grit	3 0
Binder	Shale	4 0
Slate	Slaty shale, with abundance of ironstone nodules	15 0
Timber Vein, so called from the quantity of timber required to support the roof	*Stone-coal*, with abundance of mineral charcoal at the bottom	from 5ft. 0in. to 6 0
Dunstone	Shale	3 0
Rock	Siliceous grit	unknown.

Upon a flat between the villages of Begelly and Jefferston there are some singular basin-shaped masses of stone-coal. The easternmost was discovered in 1818. It resembles in shape a semi-oval, the section passing through the longer axis. Its length from east to west is about one hundred and forty yards; its breadth from north to south, forty yards; its depth, ten yards. This mass of stone-coal is covered to the depth of two feet by yellow clay, containing rounded pieces of compact siliceous grit: it rests also upon clay.

At the distance of twenty yards to the west-north-west of the above, a similar basin of stone-coal is now worked, which is probably of nearly the same dimensions with the former; but its limits are not yet exactly ascertained. Three similar basins, though very small, are found to the west and north of the second. All these are covered by clay containing rounded pieces of grit. It is difficult to account for these basins, since in their immediate neighbourhood the strata dip gently to the south-west.

At several places on the southern and northern limits of the basin the lowest of the coal-measures are very thick, and consist of a very compact quartzose sandstone, equivalent probably to the millstone grit of other coal-fields. A bed of this rock occurs above the limestone at Gouldtrop Road; large blocks of it are

found at Rosepool; it intervenes between coal-shale and old red sandstone at Langum; is contorted together with limestone at Langum Ferry; and is seen on the edge of the coal-measures at Lawrenny Newton. These very thick quartzose beds do not appear at Tenby; siliceous grit of moderate thickness, and shale containing two or three beds of limestone, forming there the lowest of the coal-measures. The shale and limestone are seen between the sluice-wall and the descent to the bathing machines. On the northern edge of the coal-basin, from Mynwer to that part of Marcroes Mountain which faces Pendine Cliffs, large blocks of compact quartzose sandstone are found on the surface; and in Pendine Cliffs seven or eight beds of that rock are seen supporting the other coal-measures.

To the north of the western termination in St. Bride's Bay of the great coal-basin, but separated from it by greywacké, a smaller coal district occurs, which is probably connected with the great basin by intermediate submarine strata, lapping round the greywacké of Druson. This district is bounded on the west by the shores of St. Bride's Bay from Newgate Bridge to Druson Haven. On the north-east it runs up from Brawdy Mill nearly to Eweston, but it does not rise the hill at Broomhill, nor that above Brawdy Mill. The tongue of land coming down from Eweston, and the valleys on either side, belong to it. For the other limits of this district I refer to the Map. (Pl. I.)

Excepting a small space between Bathesland and Roche, where trap is intruded, the whole of this smaller district is bounded by greywacké. The coal-measures are often contorted, and at Druson Haven are set rather abruptly on greywacké. (See Pl. II. fig. 1.) Like the measures of the principal basin, they yield only stone-coal.

II.—*On the Lias of the Coast, in the Vicinity of Lyme Regis, Dorset.*

By H. T. De la BECHE, Esq. F.R., L. and G. S.S. etc.

[Read November 21st, 1823.]

In a former communication to the Geological Society I presented an outline of the features of the coast in the vicinity of Lyme Regis; but having there described the lias only in a general manner, it is my present purpose to offer a more detailed account of that formation, as I am not acquainted with any situation where its geological structure and composition, and the organic remains which it contains, can be better studied. The relative position of the cliffs referred to in the following description is represented in the section connected with my former paper upon this subject*:—And the annexed sketch (Pl. III. fig. 1.) represents the order of superposition of the inferior oolite sands, the lias formation, and the upper beds of the red marl, as they appear in the section between Down Cliff and Culverhole Point; the beds being supposed to be placed horizontally above each other, and the superincumbent chalk and green-sand removed.

The uppermost beds of the lias rise from beneath the sands of the inferior oolite at Down Cliff, on the west of Bridport Harbour; where a section is afforded of about one hundred and eighty feet of sand, in which large flattened masses of limestone occur, containing Pectens, Belemnites, Terebratulæ, &c. These sands are calcareo-siliceous, their colour is a ferruginous yellow, and they contain an abundance of mica in their lower parts. A bed of grey marl occurs in them about one hundred feet above the commencement of the lias.

The calcareous beds of the inferior oolite are not exposed in the section at Down Cliff; but they are found resting on the sands, in the continuation of the same hill, on the northern side of the London Road, being there worked at what are usually named the Chidiock Quarries.

* Geological Transactions, second series, vol. i. Pl. VIII.

It is unnecessary to trace the oolite more to the eastward, it being sufficient for my present purpose to show, that the sands which rest on the lias marl at Down Cliff belong to that stratum.

The Lias, in the tract about to be described, may be divided into three portions*: the first, and uppermost, consisting principally of beds of marl; the second, to which the denomination Lias has usually been confined, of thin beds of limestone alternating with clay; and the third, composed chiefly of marl beds immediately incumbent on the red marl or newer-sandstone formation. I shall describe each of these divisions in the order of this enumeration.

I. The Upper Lias Marls occupy a large extent of coast, forming the base of Down Cliff, the whole of the cliffs beneath the green-sand at Golden Cap, Shorne Cliff, and the greater part of Black Ven. The upper strata of these marls, as exhibited at Down Cliff, contain a considerable quantity of mica; but this character does not extend any great thickness, for the marls on the beach between the little hamlet of Sea-town and Golden Cap do not contain that mineral. Those portions of the marl which have fallen over from above, from the place where these beds come into contact with the green sand at Golden Cap, are also micaceous, being the continuation of the marls at the base of Down Cliff.

Numerous organic remains are found in the marls on the shore, between Sea-town and the rocky points projecting into the sea under Golden Cap: the most abundant are belemnites, which, though they occur throughout the greater part of the lias formation in the vicinity of Lyme, are nowhere so abundant as in the upper marls. The Ammonites Bechei of Sowerby is also a common fossil in the same situation; which likewise affords Terebratulæ, Trochus anglicus, T. imbricatus, Ammonites Grenovii, Pentacrinites subangularis (of Miller), disjointed portions of Pentacrinites Briareus, lignite, the rare remains of an echinite, the bones of Ichthyosaurus tenuirostris, &c.

The thickness of the marl exhibited at Golden Cap must be about two hundred feet; which, placed upon the three hundred feet of marls exposed in the lower part of Black Ven, would give five hundred feet as the probable thickness of this portion of the lias in the vicinity of Lyme: the marly beds at Shorne Cliff and in the upper portion of Black Ven being a continuation of

* See Conybeare and Phillips, "Outlines," &c. p. 261.

those of Golden Cap. The following list details the beds, in a descending order, in the section disclosed at the base of Black Ven.

Section of the Upper Marl beds of the Lias, at the Base of Black Ven.

	Thickness. Ft.	In.
Marls and slaty marls, with several beds of indurated marl and earthy limestone.	100	0
Irregular bed of limestone, with rounded nodules, frequently containing ammonites . .	2	0
Slaty marls, with several thin beds of indurated marl. . .	67	0
Slaty marls, containing small crystals of selenite . . .	32	0
Indurated marl, containing small plicated terebratulæ . .	4	0
Slaty marls	18	0
Earthy limestone	0	4
Marls and slaty marls (above a limestone bed ten inches in thickness)	5	0

Organic remains are abundant in some parts of the lias marl:—flattened ammonites occur in some of the slaty varieties; but the best preserved specimens of that genus are found in the rounded nodules of argillaceous limestone which occur within the marls.—These are of various species; such as A. obtusus, A. armatus, A. stellaris, &c. Plicated terebratulæ are also common. And the marls also contain the remains of Ichthyosauri, Plesiosauri, Pentacrinites, lignite, &c. The Gryphæa incurva and Plagiostoma gigantea, though found in the marly beds, are more abundant in the limestones of the lias.

II. The Lias Limestones may be said to commence with a series of thin beds varying from earthy to compact, and alternating with thin beds of marl. They rise from beneath the marls on the western side of Black Ven, and continue from thence to the Church-Cliffs immediately on the east of Lyme; but four or five small faults throw them down, and prevent their rising so high at Lyme as they otherwise would have done: and at that place there must be a considerable fault,—probably in the line of the long ledge, dry at low water, which extends into the sea opposite the eastern part of the town; since the lias marls are there again brought down nearly to the level of the sea, and are continued from the town to the western side of the Cobb.—It is clearly seen that this marl is not inferior to the limestones of the Church-Cliffs (between the Cobb and the town of Lyme); for both the marls and the limestones can be identified on each side of the town.

From a short distance west of the Cobb, to Seven-rock Point*, the lias limestones are exposed at the lower part of the cliff; and the cliffs afford a

* This name is erroneously printed "*Saren*-Rock-Point" in Plate VIII. vol. i.

nearly complete section of them, between Seven-rock Point and the large fault at the bottom of Pinhay Bay. The lias marls come close down to the point; after which the following beds occur, in a descending order:

Section of the Lias Limestone beds, near Seven-rock Point.

	Thickness. Ft.	In.
Grey limestone	0	10
Slaty marl	0	3
Grey limestone (with a seam of numerous flat ammonites at the top)	0	7
Dark marls (containing an interrupted line of limestone.—Pectens in the marl)	3	0
Greyish limestone	0	9
Dark slaty marl	1	2
Grey limestone	0	8
Marl, and slaty marl	4	6
Grey limestone	0	8
Dark marls	1	0
Grey limestone (varying from 6 inches to 1 foot)	0	9
Dark slaty marls	1	4
Rather compact grey limestone	0	7
Dark slaty marls	2	0
Grey marly limestone	0	7
Thin seam of slaty marl	0	0
Two beds of rather compact grey limestone, separated by a thin seam of slaty marl	1	0
Slaty marls	3	0
Grey limestone, with Plagiostomæ (varying from 4 to 6 inches)	0	5
Thin seam of slaty marl	0	0
Grey limestone (varying from 4 to 6 inches)	0	5
Thin seam of slaty marl	0	0
Grey limestone (varying from 4 to 7 inches)	0	6
Thin seam of slaty marl	0	0
Grey limestone	0	4
Thin seam of slaty marl	0	0
Grey compact limestone (varying from 6 inches to 1 foot)	0	9
Slaty marl	0	8
Grey limestone (2 to 4 inches)	0	3
Thin seam of marl	0	0
Grey compact limestone (8 to 12 inches)	0	10
Slaty marl	0	10
Grey compact limestone	0	4
Thin seam of slaty marl Thin bed of grey limestone Thin seam of slaty marl	0	3
Grey limestone (varying from 4 to 10 inches)	0	7
Thin seam of slaty marl	0	0
Grey limestone (2 to 4 inches)	0	3
Slaty marl	0	4
Grey limestone Slaty marl Limestone Slaty marl Grey limestone — in thin beds	0	10
Dark slaty marl	0	9
Six thin beds of grey limestone, alternating with five thin seams of marl	3	6
Marl	0	5
Grey limestone	0	3
Three thin beds of slaty marl, with three alternate beds of grey limestone	2	0
Slaty marl	0	4
Alternations of thin limestone beds with marl beds	3	0
Marl	0	10
Grey limestone (6 to 8 inches)	0	7
Slaty marl	0	8
Compact grey limestone (4 to 6 inches)	0	5
Dark marl	0	4

	Thickness. Ft.	In.
Compact grey limestone	0	4
Dark slaty marl	1	2
Compact grey limestone, with abundant remains of Plagiostomæ and Gryphæa incurva; (varying from 4 to 9 inches)	0	6½
Marl and slaty marl, with oysters (Gryphites?) and Plagiostomæ	1	0
Compact grey limestone (4 to 6 inches)	0	5
Dark marl	0	4
Compact grey limestone	0	4
Dark marl, with flat elongated nodules	2	0
Nodular grey limestone (2 to 4 inches)	0	3
Dark marl	0	3
Nodular compact grey limestone (2 to 6 inches)	0	4
Slaty marl	3	0
Compact grey limestone	0	3
Dark marl	0	3
Eight thin limestone beds, alternating with eight thin marl beds	3	0
Compact grey limestone	0	8
Slaty marl	3	0
Compact limestone	0	6
Thin seam of marl	0	0
Compact grey limestone	0	4
Slaty marl	0	4
Compact grey limestone	0	4
Dark marl	2	6

	Thickness. Ft.	In.
Grey limestone	0	5
Thin seam of marl	0	0
Compact grey limestone	0	5
Thin marl bed Thin grey limestone bed Thin marl bed	0	6
Grey limestone	0	6
Slaty marl	0	6
Grey limestone	0	5
Dark slaty marl	0	8
Yellowish earthy limestone	0	3
Thin seam of yellowish white marl	0	0
Yellowish white limestone mixed with grey, containing numerous casts of univalves, bivalves, and small corals (varying from 4 to 6 inches)	0	5
Thin seam of marl	0	0
Yellowish white limestone	0	5
Thin seam of marl	0	0
Yellowish white limestone	0	6
Indurated grey marl	0	6
Thin bed of light-coloured marl	0	0
Yellowish white limestone, some portions of which are rather compact, and others marly, but the general character is earthy;—in obscurely divided beds	18	0

Several faults are observable in the strata of the lias formation, between the rise of the four-foot marl bed beneath Black Ven, and Culverhole Point; ten such faults at least, of various extent, being exposed to view, and many more probably concealed beneath the fallen masses of chalk and green sand. In several places these fissures may be traced to a considerable distance among the horizontal ledges of rock which are dry at low water; and in one instance the termination of the crack constituting the fault is discernible on the shore near Seven-rock Point. This fissure, which is easily recognised in the cliff, is visible for some distance, running out towards the sea; but after continuing for several yards in an uniform direction, the beds unite, and at that place form a considerable curvature. The fault at the bottom of Pinhay Cliff is represented in Pl. III. fig. 2.

On the west of the fault in Pinhay Bay the limestones are thrown down about the thickness of the great bed of white lias; the dark marl beneath that bed, on the east of the fault, being in a line with the upper part of the white lias on the west of it: but after being thus thrown down, the strata rise again towards the west, so that the upper beds of the subjacent red marl emerge from beneath them near Humble Rock. Between that place and Culverhole Point the lias beds come down again to the level of the shore, and are there visible, for the last time on this part of the coast, above the red marl.

III. The beds which occur between the white lias limestones and the upper light blueish-green beds of the marl belonging to the new red sandstone formation, and which complete the section of the lias, are best exposed at Culverhole Point, under Dowlands.—They are as follow:

Section of the Lower Marl beds of the Lias, at Culverhole Point.

	Thickness. Ft.	In.
Dark marl	3	0
Earthy dark grey limestone	0	10
Dark grey slaty marl	5	0
Irregular light grey limestone	0	10
Dark slaty marl	1	4
Compact grey limestone	0	10

	Thickness. Ft.	In.
Dark slaty marl; which rests immediately on the light blueish-green beds belonging to the upper part of the new red-sandstone formation	7	0

From the sections above given it would appear, that the lias formation in the vicinity of Lyme Regis consists of an alternation of more than seventy-two beds of limestone, with an equal number of marl beds, amounting together to about one hundred and ten feet in thickness, and surmounted by about five hundred feet of marl.

IV. The lias limestones in the vicinity of Lyme contain numerous organic remains, among which those of the Ichthyosaurus and Plesiosaurus are the most remarkable; and these are found principally in the marls alternating with the limestones. The characteristic fossils of the lias,—as the Gryphæa incurva, Ammonites Bucklandi, and Plagiostoma gigantea, are by no means uncommon here, and most generally occur in the limestone beds.

The following is a list of the fossils found in the lias formation, generally, of this neighbourhood:

Organic Remains contained in the Lias Formation, in the Vicinity of Lyme Regis.

Saurian Animals.

Ichthyosaurus communis.
platyodon.
tenuirostris.
intermedius.

Plesiosaurus dolichodeirus. (Geol. Trans. second series, vol. i.)

Fish.

1. Dapedium politum. (Geol. Trans. second series, vol. i. Pl. VI.)
2. A longer fish. (Ibid. Pl. VII. fig. 1.)
3. A fossil fish, in whose mouth the teeth are arranged in the same manner as in that of the shark. (Ibid. Pl. V. figs. 3. and 4.)
4. A jaw, apparently that of a fish, differing from the preceding, is represented in the present volume, Pl. IV. fig. 1.
5. Another jaw, apparently of a fish, is represented in Pl. IV. fig. 2.
6. The head of another fish decidedly different from the preceding has also been found.

In addition to the above remains of fish, are the radii, and their accompanying palates, which I have formerly described (Geol. Trans. second series, vol. i. p. 43, 44. Plates IV. and V.); and three species, at least, of the former occur in the lias of Lyme *.

Crustacea.

Several specimens of this class have been found; but they generally occur much flattened, and in an obscure state. That represented in Pl. IV. fig. 3, is in the cabinet of Miss Philpot of Lyme.

Testaceous Molluscæ.

Chambered Univalves.

Nautilus striatus;—Sowerby's Mineral Conchol. Tab. 182.
intermedius; ibid. T. 125.

Ammonites stellaris; T. 93.
communis; T. 107. figs. 2. 3.
Discus; T. 12.

* The class of beings to which these radii belonged must have existed during a very remote geological period, as well as at an epoch comparatively recent: for bones of this description, though belonging obviously to different species, are found in the transition limestone of Dudley (from whence Mr. W. Clayfield possesses a specimen); in the carboniferous limestone at Clifton; in the lias; the oolite formation; and the chalk.

Ammonites fimbriatus; T. 164.
obtusus; T. 167.
armatus; T. 95.
Bucklandi; T. 130.
planicostatus; T. 73.
Greenovii; T. 132.
Henleii; T. 172.
Loscombi; T. 183.
Brookii; T. 190.
Ammonites Birchii; T. 267.
Königi; T. 263.
Bechei; T. 280.
Davœi; T. 350.
ellipticus; T. 92.
Belemnites, common and fusiform varieties.
Orthocera elongata*. Pl. IV. fig. 4. of this volume.

Univalves not chambered.

Trochus anglicus; Sowerby. Tab. 142.
imbricatus; T. 272. fig. 3.
Turbo.
Helicina expansa; T. 273.
Melania.

Irregular Univalves.

Serpula.—This is a rare fossil in the lias: but I possess a specimen, changed into pyrites, adhering to a belemnite.

Bivalves.

Gryphæa incurva;—Sowerb. Tab. 112.
Avicula inequivalvis; T. 244.
Pinna.
Ostrea.
Spirifer Walcotti; T. 377.
Modiola Scalprum; T. 248. fig. 2.
Hillana; T. 212. fig. 2.
Cucullæa.
Unio?
Plagiostoma gigantea; T. 77.
Astarte.
Pecten.
Terebratula crumena; T. 83. fig. 3.
ornithocephala; T. 101.
Nucula.
Cytherea.
Lucina?
Crenatula?†

Echini.

This family is very rare in the lias formation: the specimen represented in Pl. IV. fig. 5, is from the lias marl. I have seen also another species, but the specimens are not sufficiently distinct to be accurately classed.

* I have ventured to class this specimen as an Orthocera, as it possesses more of the character of that genus than of the Belemnite, the external shell not exhibiting the radiating fracture of the latter; and I have given it a specific name from its great length in proportion to the diameter. Mrs. White, to whom I am indebted for the specimen, informs me that it was originally considerably longer than at present.

† Besides the shells mentioned in the preceding list, numerous casts occur, which evidently belong to genera distinct from those above enumerated.

Crinoidea.

Pentacrinites Briareus. Pentacrinites basaltiformis.
subangularis.

Corals.

I have observed casts of this class in the lias of Lyme.

Vegetable Remains.

Knotted uncarbonized fossil wood, sometimes traversed by veins of calcareous spar, or sulphate of barytes;—represented in Pl. IV. fig. 6.

Lignite, generally flat—(described in Geol. Trans. second series, vol. i. p. 45.).

Plants resembling Ferns; (Geol. Trans. second series, vol. i. Pl. VII. figs. 2. and 3.).

Part of another plant; represented in Pl. IV. fig. 7. of this volume.

Septaria are not uncommon in the lias marls: they frequently contain ammonites in their centre, but are sometimes entirely without organic remains.

Crystallized minerals are rare in this formation; iron pyrites, selenite, calcareous spar, and two or three varieties of sulphate of barytes, nearly completing the list. The pyrites frequently occurs in forms resembling those of mushrooms.

V. The following list of the beds between the white lias at Culverhole Point, and Axmouth Point, although not relating to the immediate object of the present paper, may be interesting, as it illustrates the upper part of the extensive new red-sandstone formation of Devonshire.

Section of the upper part of the New Red-Sandstone, near Axmouth Point.

	Thickness. Ft.	In.
Light blueish-green marl, immediately beneath the lias marl	8	0
Thin seam of dark grey marl	0	0
Light-coloured indurated marl*	0	5
Dark grey marl, with a seam of light-coloured indurated marl	0	11
Light-coloured indurated marl	0	4
Dark grey marl	0	5
Irregular, indurated, light-coloured marl bed	0	5
Dark grey marl, with a light-coloured seam	2	0
Light-coloured indurated marl	5	0
Dark and light marl, with three thin light-coloured beds	2	0
Dark marl	0	5

* This light-coloured bed, and three or four other beds close to it, effervesce in different degrees with acids, and might be termed very earthy limestone.

	Thickness, Ft.	In.
Light-coloured marl	0	5
Dark marls, with nodules of indurated marl	0	6
Light-coloured marl, with lumps of gypsum	8	0
Dark marl	2	0
Indurated light-coloured marl	0	5
Light blueish-green marl	2	0
Indurated light-coloured marl	0	7
Light blueish-green marl	1	4
Light-coloured marl	1	0
Light-coloured indurated marl	0	6
Light blueish-green marl	1	0
Light-coloured indurated marl	0	4
Light blueish-green marl	1	2
Indurated marl	0	4
Light blueish-green marl, with a seam of indurated marl	0	7
Light-coloured indurated marl	0	10
Light blueish-green marl	0	8
Rather indurated light-coloured marl	1	8
Light blueish-green marl	0	8
Indurated light-coloured marl	0	7
Light blueish-green marl	0	5
Light-coloured marl	1	4
Indurated marl, the top and bottom of the bed of a red tint	2	0
Light blueish-green marl with a tint of red	0	8
Blueish-green indurated marl, with a red tint in some places	0	8

	Thickness. Ft.	In.
Thin seam of marl	0	0
Light-coloured indurated marl	0	4
Thin seam of marl	0	0
Light-coloured indurated marl	0	2
Marl, with two dark grey seams	2	0
Thin seam of rose-coloured gypsum	0	0
Light blueish-grey marl	1	6
Marl tinged with red	0	7
Blueish-green marl	0	6
Indurated marl of a reddish tint	0	8
Dark blueish-green marl	0	8
Indurated marl of a reddish tint	0	5
Dark blueish-green marl	0	7
Thin seam of rose-coloured gypsum*	0	0
Indurated marl of a red tint	0	6
Dark marl	3	0
Indurated light-coloured marl	2	0
Light-coloured marl	2	0
Thin seam of dark marl	0	0
Indurated marl, of a red tint	1	0
Seam of dark blueish-green marl	0	0
Marl of a red tint	0	5
Blueish-green marl	1	2
Indurated light-coloured marl	0	10
Blueish-green marl	1	6
Marl with a red tint	0	7
Blueish-green marl	0	10
Indurated light-coloured marl	0	8
Light blueish-green marl	2	0
Alternation of red and blueish-green marl	7	0

The total thickness of the red marl beds exposed between Culverhole and Axmouth Points may be about one hundred and twenty feet; the section exhibiting a few small faults, and a considerable curvature of the strata. After numerous alternations of blueish-green and red marl, the latter colour gradually becomes predominant, with a few occasional patches of green. The blueish-green patches, in the lower part of the section above given, afford traces of gypsum.

* At Branscombe, where a deeper part of the red marl section is exposed, gypsum is much more abundant; and mountain leather, or mountain paper, sometimes containing small crystals of celestine, occurs along with it at that place.

III.—*Observations on the Strata at Hastings, in Sussex.*

By Thomas WEBSTER, Esq., Secretary to the Geological Society.

[Read June 4th 1824.]

THE sea-cliffs on each side of the town of Hastings exhibit a section of the beds which lie below the clay of the wealds of Kent, Surrey, and Sussex, and furnish a key to understanding the structure of the high country which is surrounded by this clay and has hitherto been but imperfectly explored. In the present communication, I propose to give some account of the line of coast extending from the White Rock on the west of Hastings to Cliff End near to Winchelsea on the east.

Along this extent (Pl. V.) several valleys of denudation occur, which have separated the cliff into different portions. One of these valleys divides the White Rock from the West Cliff on which are the ruins of the ancient castle; in another, which divides the East from the West Cliff, the town of Hastings is built. In the middle of East Cliff is the romantic valley where the stream called Eaglesbourne forms the well-known fish-ponds; and to the east of East Cliff, and between it and Fairlee Cliff, is the place called the Govers. At Cliff End the cliff terminates, and gives place to the valley that goes up to Winchelsea.

When we view this coast from the sea, we may perceive that the beds of rock form a vast, but irregular, arch, dipping at each end under the Weald clay, and rising in the middle to the greatest height in the neighbourhood of Hastings, where they may be advantageously studied.

In endeavouring to subdivide this mass of strata, a remarkable want of continuity and regularity may be noticed, which renders their examination difficult.

The distinguishing features in the detail appear to be, that in the upper part a hard grey-coloured calciferous sandstone abounds; the middle part consists mostly of a yellow soft friable sandstone; and the lower part is composed of beds of clay, shale, and ferruginous sandstone, with several layers of ironstone, and numerous fragments of carbonized vegetables.

The grey calciferous rock is that which, several years since, first drew my

attention to the mineralogical nature of these cliffs. Many large blocks of it, sometimes 10 or 12 feet long, lie on the shore in a very picturesque manner, (See Pl. VI, fig. 2, *a, a,*) and have evidently fallen from the top of the cliff: they are broken up for paving and mending the roads, for which purposes they prove an excellent material; by their colour they are easily distinguished from the common yellowish sandstone in which they are imbedded, and which often remains firmly attached to them even after they have fallen.

These blocks of grey calciferous stone frequently have their upper and under surfaces distinctly mamillated, or formed of portions of spherical or spheroidal figures. It has been supposed by some who have noticed these fallen masses, that they have been worn into these forms by the action of the sea: but this is evidently not the case; since they are of the same shape while still lying in the sandstone cliff in places where the sea could not have reached them, the mamillary masses existing before the blocks were detached from the yellow sandstone. Fig. 1. (Plate VI.) represents a portion of this rock viewed looking towards the sea; and at *b, b, b, b,* are seen the above-mentioned blocks in their places.

The sea does indeed frequently wear the surfaces of the blocks (and many of them are seen so worn), but in a very different manner. By the friction of the pebbles put in motion by the breakers, a number of hollows or concavities are worked out, intersecting each other, and separated by sharp ridges. These, (see *c*, fig. 2, Plate VI,) somewhat resemble casts taken from the mamillated surfaces; but in the rocks worn by the pebbles there are angular projecting *ridges*; in the others, there are angular *depressions*. This mamillary appearance is too regular and constant to be owing to accident, and can be attributed only to one of the varieties of crystalline action. The rock, when fresh broken, has a peculiar glistening lustre, which reminded me of the fracture of the crystallized sandstone of Fontainbleau, (the chaux carbonatée quartzifère of Haüy). Like that substance, the mamillated rock of Hastings is a sandstone having a small quantity of carbonate of lime, which however, involving the sand, has been sufficient to occasion the concretionary structure. It is however remarkable, that the stone is composed of thin layers of sand parallel to the bases of the mamillary projections; from which it would seem, that those masses had at first been sand, and that the calcareous matter which obeyed the crystalline influence had been introduced, or at least diffused through it, subsequently.

From the size of the masses in the cliff, they often, at first sight, resemble beds alternating with the sandstone; and it is only by a close examination that their want of continuity and the very irregular nature of their distribution ap-

pears, which must be accounted for from their concretionary nature. The place where these mammillated masses are best seen is at White Rock, as they are there easily accessible while still in their original situations. One which I measured at that place exceeded 15 feet in length, being about 2 feet in thickness. Excellent examples also lie on the shore below East Cliff, from whence they have fallen; but they cannot be easily examined *in situ* at that place.

I have stated that they lie in the upper part of the series. At the White Rock they are on the level of the sea: going eastwards, they rise, and keep at the top of the Cliff (*d, d, d*). They do not occur in the West Cliff under the castle; and in the East Cliff they chiefly appear in the upper part, but are much more abundant near Eaglesbourne. They do not exist between the Govers and Cliff End; but at the latter place they are again seen (*f, f*), and are also found at Winchelsea.

Below this concretionary bed, at the White Rock (*d, d*), and at East Cliff (*g, g*), there is one of dark-coloured shale 10 or 12 feet thick; and a similar bed on the highest part of West Cliff, under the castle, belongs to the latter.

Underneath this shale, at the above places, is a very thick bed of soft sandstone (*h, h, h, h*), often extremely white, which gives the chief character to the cliffs of Hastings. Besides being strongly marked by horizontal lines on its surface, occasioned by the unequal hardness of the strata, it is divided vertically by numerous deep rents and fissures. Owing to these, and to the caves that had been worked in the lower part for procuring sand, together with the failure of the subjacent clay and shale on which it rests, large masses had frequently fallen, and so much endangered the houses beneath, that the entire face of the West Cliff has lately been cut down to prevent similar accidents; a circumstance that has materially injured the picturesque beauty of the rock, but has afforded the geologist a good opportunity of examining its nature. There are, however, but few circumstances respecting it to attract notice:—it is here very white and uniform, and is composed of siliceous grains having so little coherence that large blocks thrown down from the top by the workmen became mere sand on striking the bottom.

This thick bed of sandstone forms the middle of the East Cliff; but there, numerous and very large masses of the above-mentioned concretionary rock occur in the sandstone, and these increase in quantity towards the east end near Eaglesbourne. Beyond Eaglesbourne, this bed extends to the Govers, where it is seen breaking out in the sides of the valley, and also in the romantic spot called Lover's Seat, though I believe this to be its eastern boundary.

Below this thick mass of white sand are beds of slate-clay and shale (*i, i, i, i*), containing numerous thin layers of shivery ferruginous sandstone, together

with lignite and silicified wood. This has been well exposed at West Cliff in an artificial section which has been made to afford space for new buildings (*k*). In East Cliff this shale is very conspicuous (*i, i*); and as it here rises to the east, it is found considerably above the sea, at the east end, being there at about one-third the height of the cliff. It frequently contains indistinct impressions of plants, among which ferns may be distinguished, and bears upon the whole a considerable resemblance to some coal-shales. It becomes very thin towards Eaglesbourne, divides into several portions with partial beds of sandstone between, and is not distinctly traceable further in this direction.

Under this shale is another bed of sandstone (*l, l*), very different from that above. It has no calciferous concretions, contains always more or less oxide of iron, and has a tendency to separate into rhomboidal masses, being intersected by numerous veins of argillaceous iron-ore. This bed is best seen at East Cliff, in the west end of which it appears on the level of the beach. As it rises to the east it attains a great thickness; and in its lower parts are irregular layers of clay, sometimes white and approaching to pipeclay.

These interposed clays, increasing in thickness towards the east, occupy almost the whole of Lover's Seat and the high cliff of Fairlee, and are there sometimes stained with red. The lowest strata visible in this series consist of a dark-coloured shale, which is seen at the Govers and Cliff End (*m, m*), and contain small roundish masses of sandstone, together with several layers (two of them from 2 to 3 inches thick) of rich argillaceous iron-ore: with these are found abundant thin layers of lignite, and innumerable fragments of carbonized vegetables, among which ferns are recognisable. It is from these beds that the rich iron-ores of Sussex, which were formerly much worked, have in some instances been procured; and it was from the abundance of the iron, the beds of clay and shale with vegetable impressions, and the fragments of charcoal in the sandstones, that expectations had been formed of finding coal in this formation, before the difference between lignites and true coal was generally understood. On the west of Eaglesbourne this last bed rises in an arch to the height of about 12 feet, and then descends to the east; at Cliff End it re-appears, and may be traced at low water forming a ledge.

Although the calciferous rock is the uppermost bed in these cliffs, yet inland, on ascending the high ground towards Fairlee Down, thick beds of clay and yellowish sand are seen, which appear to be superior to it in geological position; and I believe a portion of the strata immediately behind the White Rock, that is very highly inclined (*n, n,* Plate V.), belongs to this.

The cliffs at Hastings are not rich in organic remains. In the calciferous sandstone, the only indications of shells I have seen are the impressions and

casts of a small bivalve, which occur rather abundantly, but which are generally in too imperfect a state to enable the naturalist to decide to what species they belong; together with a few casts of an univalve resembling those found in the Petworth and Purbeck marbles, and which have usually been considered as fresh-water shells, perhaps Paludinæ. These fossils are sometimes also found in the sandstone not calciferous.

Besides the vegetable remains which I have already mentioned as so plentiful in the lower beds of sandstone and shaly clay, portions of the silicified stems of monocotyledonous plants are frequently found in these cliffs, of a character that deserves well the attention of the botanist. All the pieces I have seen (and they are often found on the beach) are somewhat flattened, and have longitudinal cavities of two kinds, which evidently belong to the structure of the plant: the first small, sinuous, and communicating with each other; the second much larger, but frequently compressed. Both are lined with beautiful minute and transparent crystals of pyramidal quartz, the colour of the whole being blackish brown.

In masses of the rock that have fallen from the East Cliff, I found, in 1812, numerous fragments of the ribs of large Saurian animals, one of which I placed in the collection of the Geological Society: but I am indebted to the liberality of George Cumberland, Esq., for the use of the following drawings of organic remains found by him in these cliffs.

Fig. 5. Plate VI. represents several teeth in a portion of a jaw. They are conical and polished. I have not been able to ascertain to what animal they belong, but they have considerable analogy to those of the Lizard tribe.

Fig. 6. represents the same teeth magnified. The upper part (seen again at fig. 7.), may be easily detached, and seems like a capping of a transparent substance. It is proper to add that I found the same kind of teeth in the Purbeck beds at Swanwich.

Fig. 8. Plate VI. Tooth of a fish.

Fig. 9. Plate VI. The dorsal fin of a fish.

Fig. 10. Plate VI. Bone of a bird.

Fig. 11. Plate VI. Scales of fish:—these are highly polished.

I may mention here (although it is evidently postdiluvian) the remains of what is usually called a submarine forest, which is to be seen at low water between White Rock and the West Cliff. Numerous trunks of trees lie flat, the wood partly black and partly of the natural colour: they are accompanied by great quantities of hazel-nuts.

From the character of the calciferous mammillary rock above described, and its organic remains, connected with the geography of the country, I have no

doubt of the identity of the beds forming the cliffs at Hastings with the rock that occurs in Tilgate Forest and Cuckfield, so rich in fossil bones: but from an examination of the first of these strata on an extensive line of coast in Dorsetshire, where from their highly inclined position they are well displayed, I have been much struck with the want of agreement in the details of the sections at different places. Although the strongly coloured clays and sandstones of this series may be easily recognised, yet the irregularities are so great, that it is evident the subdivisions, or separate members of this formation, are of very limited extent.

IV.—*Observations on the Purbeck and Portland Beds.*

By Thomas WEBSTER, Esq., Secretary to the Geological Society.

[Read November 19th, 1824.]

THE following communication is the result of a short visit which I paid to the Isles of Purbeck and Portland some years ago, subsequently to the publication of my Letters to Sir H. Englefield.

In that work I traced out the great features of this very interesting district; but a detailed account of the beds is yet a desideratum. To supply in the mean time some materials for such a purpose is the object of the present paper. I shall confine myself here to the beds which furnish the well-known Purbeck stone, which is extensively employed in London for the side pavement of the streets; and to the beds in the Isle of Portland from which the principal material for our public buildings has been procured.

The beds in the northern part of the Isle of Purbeck are considerably inclined; they dip to the north, coming out to the day from under a series of clays and sandstones which are the equivalents of the Hastings beds described in a former paper. The situation of all these, and their relations to the chalk, are well seen in Swanwich and Durlstone Bays, in the east end of the Isle of Purbeck, and in Warbarrow Bay on the west. Their general direction being from east to west, a very instructive section of the limestones usually known by the name of the Purbeck Beds may be advantageously studied in the latter of these places.

A line of elevated ground, consisting of these calcareous strata, extends from the town of Swanwich to Warbarrow Bay; and the northern part, as far as the village of Worth, is covered with quarries which have long been worked for the London and other markets, as well as for the supply of the neighbourhood. Quarries have lately been opened also in the most western parts.

In Durlstone Bay, the number and disposition of the beds may be well seen; on the northern part of the bay they are very regular, but about the middle of the bay they are bent and distorted in a very singular manner*:

* Several drawings which I made from these contortions have been already engraved, and published with the letters above mentioned.

at Tillywhim Quarry, in the south-east corner of the Isle of Purbeck, they may be observed reposing on an oolitic limestone which I consider as identical with part of the series of beds in the Isle of Portland. Here however, and all along the south side of the Isle of Purbeck, from Durlstone Head to St. Adhelm's Head, the strata are horizontal; and many quarries are opened in them for the stone, which is called the Purbeck Portland, and which is in general harder than that in the Isle of Portland.

On the remainder of the south coast from St. Adhelm's Head to Gad Cliff, near Warbarrow Bay, still lower beds are seen, consisting of clay and dark-coloured compact limestone, which have obtained the name of Kimmeridge beds from a village in that district.

The Isle of Portland, as is well known, is situated near to Weymouth, and is connected with the land by a bank of shingles, or water-worn pebbles, about 10 miles in length, called the Chesil Bank. Its beds dip also to the north; and on that side, under the great oolitic mass (of which the upper part of the island consists), the Kimmeridge beds are exposed.

Having thus exhibited a general view of the situation of the strata which I propose to give some account of, I shall begin by stating some particulars respecting the Purbeck limestone series.

In Durlstone Bay I obtained from the quarrymen the thickness of the several beds, and the names by which they distinguished them from each other: but I should observe that these local appellations are not used by London architects and builders, the whole together passing here under the name of Purbeck stone only.

The following is a list of the strata of limestone, which are mostly separated from each other by a thin bed of a shivery clay or shale.

Nos.	Thickness. Ft.	In.
1. Marble, not worked at present	uncertain	
2. Marble rag	8	0
Shiver, marl, &c.	20	0
3. Single leaper, good stone	1	3
Shiver, marl, &c.	2	0
4. Step bed, good stone	0	7
5. Grey rag, good stone	0	7
Shiver, marl, &c.	10	0
6. Toad's eye, a very hard but good stone	0	4
Shiver	0	1
7. Good bed, bad stone	1	0
Shiver, &c.	1	0
8. Pitching-stone bed, good stone	0	5
9. Tomb-stone bed, good stone	0	6
10. Yellow bed, bad, not worked	0	4
11. White roach, not very good	1	0
White earth, a marle	0	9
12. Leaper, excellent	1	0
13. White bed, excellent	1	0
14. Soft bed, excellent	0	7
15. Hard bed, excellent	0	6
16. Mock hard bed	0	7
Earth	1	0
17. Pitcher bed	0	6

Lane-end Vein

Nos.	Thickness. Ft.	In.
18. Backing	1	3
Shiver, &c.	3	0
19. Royal	1	0
Shiver, &c.	3	0
20. Devil's bed	0	6
Shiver, &c.	2	0
21. Iron bed	0	4
Shiver, &c.	2	0
22. Red rag	1	0
Shiver, &c.	2	0
23. Upper rag	3	0
Shiver, &c.	2	0
24. Under rag	1	6
Shiver, &c.	2	0
25. Lead bed	0	4
26. Shid bed	2	0
27. Shingle, 2 beds	1	0
Shiver, &c.	0	6
28. Grub	0	8
Shiver, &c.	0	3
29. Roach in 4 beds, good (Freestone Vein)	2	0
30. Grey bed, good (Freestone Vein)	1	0
31. Thornback, good (Freestone Vein)	1	0
32. Freestone, good (Freestone Vein)	3	0
Shiver, &c.	2	0
33. Lias, not worked	1	0
34. Lias rag		

Nos.	Thickness. Ft.	In.
35. Downs Vein rag		
Shiver	0	3
36. Grey bed, No. 2, not worked	0	8
37. Hone	0	10
Hone not worked, marly	1	6
Shiver	0	4
38. Grey bed, not worked	0	4
39. Upper bed } Downs Vein. These	1	6
40. Lower bed } divide into slates.	1	0
Shiver	0	4
41. Cinder, useless. It is a bed of oysters	12	0
Stone, not worked	0	4
42. Button; splits into slates	0	7
43. Feather, good	2	0
44. Cap, used only in backing	1	0
45. Flint, ditto	1	0
Shiver	1	6
46. Upper five-bed, sometimes splits into 5 (New Vein)	0	6
47. Under five-bed, ditto (New Vein)	0	8
48. White bed, good (New Vein)	1	8
49. Tomb-stone, good (New Vein)	0	6
50. Pudding, inferior (New Vein)	0	9
51. Sheer, used in backing	0	8
Shiver	0	5
52. Flint, used only in backing	2	0

Although most of the stony beds are used for some purpose or other, yet the quarrymen distinguish among them four principal groups, which they in the language of workmen call *veins*. It is these beds only that are worked for exportation, by means of galleries under-ground, which are carried on for a considerable way, at the expense of the individual quarrymen who are the proprietors*.

The exact point of junction of the clay and sands which are the equivalents of the Hastings beds, with the Purbeck limestone beds, cannot be seen in Swanwich Bay, as at this place there is a hollow that is level with the sea; but it may be studied in Warbarrow Bay, Lulworth Cove, and several places to the west. The bed which appears to be uppermost in the series of the Purbeck limestone is one containing a very large proportion of green earth, the calcareous matter appearing to be derived entirely from the fragments of a bivalve, of from an

* Specimens of all these may be seen in the collection of the Geological Society.

inch to an inch and a half in length; but during the short time I was on the spot I was not fortunate enough to find perfect specimens. This bed, which is of a thickness that varies from 1 foot to 2 feet or more, passes gradually into that called the Purbeck marble, which contains several univalves as well as bivalves; among which, one resembles that of the Petworth marble, and is considered by some as a Paludina, although in general a smaller species of univalve is most abundant*. The cavities of these shells are usually filled up by a compact limestone, and between them is a calcareous matter with much green earth and red oxide of iron. This circumstance occasions some specimens of the marble to have a variegated and pretty appearance; in which it differs from the Petworth, which is usually of a grey aspect.

On each side of these beds of marble, which seldom exceed 6 inches in thickness, are frequently layers of fibrous carbonate of lime and also of fibrous sulphate of lime; and considerable masses of the latter have sometimes been found.

The Purbeck marble was in ancient times much employed in England for making the slender shafts for the columns in Gothic churches, and in them many fine specimens of this rock may be seen; but the introduction of foreign marbles has occasioned its use to be discontinued. Occasionally, this marble exhibits no shells, and it is then of a greyish colour, veined with a darker grey.

The rest of the Purbeck limestone beds appear to be derived from fragments of shells, which in most instances are sufficiently evident; but the stone is sometimes almost compact. The greatest part of these fragments appear to me to have belonged to small bivalves; but it is extremely difficult to procure such specimens as can enable one to speak with any thing like certainty as to the species. That the univalves in the marble, as well as in the other beds, resembled the Helix vivipara, was observed by Woodward long ago, and I have alluded to this in one of my letters to Sir H. Englefield: but according to my own way of viewing the subject, it would be incorrect to call this a decidedly fresh-water formation, since I think this term ought to be restricted to beds supposed to have been *formed in lakes:* and I have no doubt but that the Purbeck beds in general contain a mixture of fresh-water with marine shells. I possess some specimens in which are beautiful calcedonic shells, both fresh-water and marine; and one bed in particular, called Cinder, consists almost entirely of a mass of oysters. Fossil fish, nearly as beautiful as those of Monte Bolca, are not unfrequently found in the Purbeck beds, several of which are in the museum of the Geological Society. Fragments of the bones of the turtle are also of frequent occurrence, and several entire skeletons have been

* Sometimes, however, layers are found with univalves as large as those of the Petworth marble.

found nearly entire. I have also seen fins of the balistes, and teeth of the same species of fish as I have mentioned to be found at Hastings. (See p. 35.)

As the thickness of all the formations below the chalk diminishes in a very remarkable manner in proceeding from the east end of the Isle of Purbeck westwards, so the beds that we have been considering partake of this change; for although the quarrymen can point out, in the quarries to the west (as, for instance, in one at Warbarrow), beds which they consider to correspond to the veins which they work at Swanwich, yet the greatest part of the beds to which they give names at the latter place do not exist westwards. At the quarries of Tillywhim, Warbarrow, and Mewp Bay, the junction of the proper Purbeck beds containing fragments of shells, with the beds analogous to them in the upper part of the series in the Isle of Portland, to be afterwards described, may be advantageously examined.

I shall next proceed to point out what I have observed chiefly remarkable in the Isle of Portland.

The principal quarries in this place were formerly on the north-east side; but these are now almost abandoned, and they procure the stone more conveniently on the highest part of the island at the north end. These quarries are not worked by galleries, but are all open to the day. The section of one of the principal quarries on the north end is as follows*. (See Plate VI. fig. 3.)

Immediately under the soil, which seldom exceeds a foot in depth, is a series of thin beds, all together about 3 feet thick, called *slate* by the quarrymen, which split readily into layers from an inch to half an inch in thickness. They consist of limestone of a dull yellowish colour, extremely compact, and entirely without shells (at least I have not seen any in it). In its aspect it considerably resembles those compact varieties of Purbeck stone in which the remains of shells are not visible. These are what I consider to be analogous to the beds in the lower part of the Purbeck limestone, seen at Warbarrow and Mewp Bays above mentioned.

Below this is another mass of calcareous stone, considerably softer, and of a lighter colour than the preceding: it is divided into two by a slaty bed, the upper being called *aish*, and the lower the *soft burr*. The latter stands upon a bed, about one foot thick, consisting of a dark-brown substance, and containing much earthy lignite; this bed is very remarkable, and extends all through the north end of the Isle of Portland; I even found some traces of it in the coves at the west end of Purbeck: it is called by the quarrymen the *Dirt bed*. In it are found considerable numbers of fossil trunks of trees of the dicotyledo-

* Specimens of all these beds I have placed in the collection of the Society.

nous class, which are from 1 to 2 feet in diameter. The woody part is siliceous, and the longitudinal vessels are filled by, and surrounded with, radiated quartz: numerous veins of chalcedony and quartz also pass through these stems, but always following the direction of the concentric and radial structure. In the cavities, and particularly on the outside, there is a small quantity of carbonate of lime; but this is only superficial, and has been a deposit subsequent to the silex. I saw one of these trunks standing erect, and the workmen informed me they were frequently found in this position: its lower part was thickest, and being divided, it gave the idea of the commencement of roots: its upper part penetrated through the *soft burr* and terminated in the *aish*. The trunks are always broken off short, seldom exceeding 3 feet in length. This is the fossil wood which is so often brought from the Isle of Portland; and upon the most careful inquiry and examination, I could not discover that it was found in the oolite itself, nor in any other part of the series. In this earthy bed are also many stones evidently water-worn, which I afterwards ascertained to belong to the lower part of the Portland series; one was a dark grey splintery limestone, and another a brown stone slightly oolitic.

The bed below this is called the *Top Cap*, and varies considerably in its structure. Some parts of it are entirely compact; in other places it contains compact parts imbedded in a softer rock; and in others again it is slightly cellular; but, as far as I could discover, contains no fossils.

The next bed is called the *School Cap*, and is of a very remarkable structure; it consists of a compact limestone extremely cellular, the cavities being almost filled with groups of rhomboidal crystals of carbonate of lime.

Under the School Cap is a layer 6 inches thick of flint, or *chert*, containing shells, and often having also oolitic grains imbedded.

The bed below this is the first which is worked for freestone, and is called *Roach*. Its thickness is variable; in the quarry which I measured, it is 15 feet thick, and without subdivision. This is the most valuable bed, and blocks of vast size are raised from it for the London market. It is entirely oolitic, and generally of a very uniform quality. It contains marine shells, as oysters, various bivalves, and likewise the Hallirhoë of Lamouroux, but the organic bodies are not numerous.

The next bed, called the *Rubbly Bed*, is remarkable for the quantity of casts of shells which it contains. This renders it unfit for building, except for filling-in thick walls and foundations. It is also oolitic; and, except that the shells occasion cavities, is nearly as firm as the Roach.

Below the Rubbly bed is another of excellent stone, but sometimes rather harder than the Roach. This is about 6 feet thick, and is also worked when

found in convenient situations. Beneath this, the quality of the rock changes considerably; it becomes more varied in its texture, and is much mixed with chert. Some parts of it are not oolitic, but grey, and of a splintery fracture; other parts are brownish and slightly oolitic; while others again are very soft and white, and contain bodies resembling parts of coleopterous insects. This last portion was within 18 inches of the Kimmeridge beds. It is rather to the lower, than to the upper bed, of the good stone of Portland, that I refer the Purbeck Portland, which is generally but slightly oolitic, and contains much calcareous spar: this renders it a harder stone, and fitter for many purposes of building where durability is required. I should state that with the Purbeck Portland is also found another stone not at all oolitic, but granular, and resembling exactly the stone of Caen in Normandy, which, it is well known, was formerly imported into this country, and much employed in sculpture.

I examined also several other quarries at the north end of the Island, where the same beds, and nearly in the same proportion, could be distinguished: but on the south-east side, where quarries are also worked, the beds differ considerably in their subdivisions. The Slate and Cap occur, but not the lignite; and the Roach, though still considerable, was subdivided into 3 beds; below which the chert was in greater quantity than on the north side. At the south end of the island, from the dip being to the south, the top of the series came within about 20 or 30 feet of the sea, and the lower beds were invisible. There are no quarries in this part.

Immediately below this great calcareous series, in the Isle of Portland, are seen very thick beds of bituminous clay and bituminous limestone, resembling those at Kimmeridge which I had before visited: but as it is not my object at present to enter into the consideration of the Kimmeridge strata; I shall only now state that the identification of the beds at the base of Portland Island and at Kimmeridge is, I conceive, as complete as such a subject admits of.

Having now taken a rapid view of these two series, viz. the Purbeck and Portland beds, which well deserve a still more particular examination, I cannot help stating that there appears sufficient reason for keeping them separate from each other in grouping the strata. Perhaps no distinction is more remarkable than that depending upon the organic remains derived from fresh-water and marine animals; and although this subject, and the mode of recognising the fossil remains, be extremely difficult and obscure, yet the facts I shall proceed to state, added to so wide a variation in mineralogical character, may perhaps justify my opinion.

I have in another place alluded to the analogy between the Purbeck beds

and the beds in the Weald clay, called, in the Isle of Wight, Platten, and in Sussex, Petworth Marble : that the shells in the latter are fresh-water shells, is an opinion which has been advanced by several geologists. The most abundant of the small univalves and bivalves in the Purbeck beds are the same as those in the Hastings rock, which contains scarcely any other shell. Beds of the latter are quarried near Battle Abbey in Sussex, having a very close resemblance to some of those in Purbeck, and like them are separated from each other by shale. These and other circumstances may lead us to unite the Purbeck beds, the Hastings beds, and the Weald clay into one group; while the same reasons will tend to remove the Purbeck beds from the Portland rock, which contains a suite of marine shells only, as the Turritella, Trigonia, &c.; added to this, I have no where seen in the Purbeck or Hastings beds any of those oolitic grains of which the Portland almost entirely consists.

The chief question is, perhaps, where the line should be drawn between this group and the proper oolite formation; and here, I own, I do not see my way clearly. The beds called the Top Cap have no shells to enable us to decide; but there is something in their general aspect that strongly reminds me of the fresh-water rocks in the basin of Paris, particularly that of Chateau Landon. Should this resemblance be at a future time found to be owing to similar agencies, the division may be made at the top of the chert, which is evidently connected with the oolite by its containing the same fossils.

The *Cap* of Portland has much more analogy with the lower part of the Purbeck beds than with the oolitic beds; indeed I have seen among the beds of Purbeck some not to be distinguished from the Cap of Portland.

V.—*Observations on Belemnites.*

By Mr. J. S. MILLER, A.L.S., &c. Communicated by the Rev. W. D. Conybeare, F.R.S. M.G.S., &c.

[Read April 4th, 1823.]

AN attentive examination of Belemnites has enabled me to ascertain their zoological characters, and to distinguish between the different species which have been discovered more precisely than has yet been done.

The result of this examination I have now the pleasure of laying before the Geological Society; but before I proceed to describe the characters of these fossils, it will be interesting to notice the various opinions which have at different times been entertained respecting them. We may indeed derive some useful hints from ancient names and traditions, as pointing out the countries in which particular fossils are found, and hence obtain some knowledge of the strata occurring in the places to which such traditions refer.

I. *Geological Position of Belemnites, and a Sketch of the Opinions that have been entertained respecting their Origin.*

The geological position of Belemnites is in the lias and in the strata above it, as high as the chalk inclusive. None have ever been found in beds older than the new red-sandstone on the one hand, nor on the other in any of the formations above the chalk. They also occur frequently detached and bouldered among gravel and alluvial soils, the compactness of their substance having preserved them from complete destruction. In the beds to which they belong they occur in association with the remains of marine animals, and are so frequently met with that it is evident they were by no means rare in the seas in which they lived.

The term Belemnite is derived from βελεμνον, a dart or arrow, which the fossil is supposed to resemble; and hence the English name *Arrowhead* and the German *Pfeilstein*.

The fanciful opinions which have at various times been entertained respecting the origin of fossil organic remains, and which are to be attributed to a

total ignorance of geology, have existed in a very remarkable degree in regard to Belemnites. These fossils appear to have been among the earliest noticed, and although in the various conjectures which have been formed respecting them we may trace a gradual progress towards the truth, their real nature has not as yet been developed. It could in fact be only by the use of those guides which the present state of knowledge of natural history has afforded, that we could successfully arrive at a solution of the question.

The ancients observed these fossils; and in Ovid's Metamorphoses it is stated that the urine of the Indian lynx became converted into stone before it reached the ground, and thus formed the Belemnites, which were therefore named Lapides Lyncis, Lyncurium, &c. Another denomination was Idæus Dactylus, probably from their having been found on Mount Ida, and from their resemblance in form to fingers, or perhaps from their having been first noticed by those celebrated metallurgists of antiquity, who obtained that title from their being ten in number.

It was for a long time a common belief that these stones were petrified fingers; and this opinion was entertained by the Northern nations, whose gloomy forests fostered a natural tendency to the mysterious, and who embellished the nomenclature of natural history with many terms referring to supernatural agency: hence the common names of this fossil in the North, *Devil's Fingers, Spectrorum Candela,* &c.

In later times the Belemnite was supposed to be produced by electricity, and was called Lapis fulminans, and Thunderbolt.

In the latter part of the 17th century all figured stones (as fossils were then called) were by many writers considered to have no relation to the organic bodies they resembled, but to be only *lusus naturæ,* concretions which had accidentally obtained those forms; and although some persons adopted a sounder opinion in regard to the common fossil shells, yet they supposed the Belemnite to be truly mineral, and either a stalactite or a crystal.

Others finding fragments of Belemnites in the sandy country of Prussia, where amber is also found, imagined them to be that substance in a petrified state.

When more accurate notions respecting fossils were adopted, and the Belemnite was observed to occur always in association with marine productions (such as shells and the bones of Saurian animals), it was supposed, on account of the conical cavity at its broader end, to be a tooth of some unknown animal, or a spine, like those of Echini. Other ideas, which appear to have been merely conjectural, existed, that they might have been Alcyonia, or even Holothuriæ.

At length the Belemnite was considered to be the remains of a testaceous animal, and a new series of theories and conjectures arose. The form and cavity then afforded grounds for referring it to the genus Dentalium.

The concave septa induced Von Tressau to consider it as a limpet.

Klein in his *Descriptiones Tubulorum Marinorum,* published at Dantzic in 1731, appears to be one of the first writers* who entertained clear notions of its nature. His generic description is as follows: "Tubulus marinus fossilis, materiæ at seleniticam accedentis; teres; transversim fractus concentricis striis, in longitudinem fissus canaliculo pervio semper in medio posito donatus; in basi nonnunquam fovens conum olim testaceum concameratum, instructum siphunculo."

Breynius†, Da Costa, and Brander‡ added but little to the observations of Klein.

Plott, in the Philosophical Transactions for 1764, considerably extends our knowledge of the structure of the Belemnite, though an ignorance of the true nature of the molluscæ inhabiting the chambered univalves has led him to maintain several erroneous opinions with regard to the exact mode of its formation. He observes that the concave septa in the superior conical shell were connected by a siphuncle, and suggests that the animal lived in its outer chamber: he also considers the shell as having sustained no change, and proves this from the vestiges of its laminar construction, which he compares to that of the oyster. Yet Plott does not agree with Dr. Hooke, that the siphuncle extends through all the chambers; and gives a rather unsatisfactory account of the manner in which the animal is, according to his hypothesis, to leave the aperture of its first chamber without separating from the siphuncle, and to assume a figure which may permit it to crawl on the bottom of the sea and to drag its shell with it. He states that the animal, both on its return and in its progress, clasps the whole guard by two flaps or sides of its mantle, as a snail does a small branch of a tree, and that in so doing it deposits by excretion the lamellæ which form the guard (in a manner very similar to that in which the Cypræa increases its shell). The sulcus, which may be observed traversing the surface of the Belemnite longitudinally, he considers as indicating the interval in which the two flaps of the mantle must have met in thus clasping the guard.

As the chambered portion of the Belemnite is so closely analogous to the shell of the Nautilus,—Walch, Parkinson, and Lamarck agree in the opinion that, like that shell, it was destined to aid the buoyancy of its inhabitant: but

* Rosinus perhaps at an earlier time had published ideas corresponding with those of Klein, but I have no opportunity of referring to his work.

† Dissertatio de Polythalamiis.

‡ Phil. Trans.

the great difficulty was, how so small an apparatus should move so heavy a spathose body as the protecting shell or guard. To overcome this, each of the authors created a theory, agreeing in the conclusion, that the guard was originally light and porous, and has obtained its present solidity by the process of petrifaction.

Walch conceives that the guard of the Belemnite was formed of two hollow shells, inclosing a viscous fluid; the chambered cone being inserted into this cavity, its siphuncle passing through the fluid and terminating at the point of the shell. On this view the fluid in question would have produced specific lightness, and might as he conceives have been converted into radiating spar, and thus furnished the present appearance.

Mr. Parkinson supposed that the guard as well as the chambered apparatus was intended to increase the animal buoyancy. Hence, from a resemblance of the guard to some supposed echinital spines in the chalk, he refers to the internal organization of echinital spines; and finding this to be porous or cork-like, he conceives the guard to have been originally of a similar consistency, but now altered by the infiltration of calcareous spar. He further thinks, with reference to the tube observed by Walch as existing in the Belemnitic guard, that it might have been a continuation of the siphuncle; and this, communicating with the cellular substance of the guard, might by the admission of air or water have served to regulate the buoyancy thus acquired.

Lamarck conceives that the Belemnite was an internal shell once inclosed within the body of the animal, similar to the bone of the Sepia, and consequently like that bone, of a spongy or cellular form.

II. *Generic character.*

Genus. *Belemnites.* A cephalopodous? molluscous animal provided with a fibrous spathose conical shell, divided by transverse concave septa into separate cells or chambers connected by a siphuncle; and inserted into a laminar, solid, fibrous, spathose, subconical or fusiform body extending beyond it, and forming a protecting guard or sheath.

III. *Observations.*

I have already observed that the Belemnites are now admitted to have inhabited the sea; but as we are not acquainted with any living animals possessed of a similar structure, we must necessarily form our ideas respecting the animal of the Belemnite from the hints which its shell is capable of furnishing, by the muscular impressions it exhibits, and by its analogy to other testacea.

The conical chambered shell is easily separated by decomposition from its protecting guard, which being of a solid laminar spathose substance is very

durable, while the fragile texture of the chambered portion has rendered it liable to be destroyed by the least violence; and consequently this part has been preserved only when its chambers were filled with mineral matter; and even then a subsequent decomposition of the transverse septa has frequently separated the series of casts formed within the chambers.

The chambered structure of the conical shell of the Belemnite, and its siphuncle, exhibit a striking analogy with the Orthoceratite, the Nautilus, and the Ammonite. It differs, however, essentially from the Orthoceratite in the circumstance that all parts of its shell present on fracture a laminar fibrous spathose substance; in its being provided at its posterior end with a more or less elongated and encompassing guard or sheath; and in the siphuncle of the chambered cone being situated near the margin. This last character, combined with the fibrous and spathose texture of the shell, will at all times, in my opinion, afford a discriminating character between the chambered cone of a Belemnite (even when occurring separated from its guard) and the Orthoceratite.

From this analogy of the Belemnite to the Nautilus in the chambered parts of the shell, it appeared probable that, like the latter, it could be made buoyant at the will of the animal. But as my examination of the guard had led me to the conclusion that this part had been at its first formation solid and spathose as it is at present, a difficulty presented itself, as, although the form and weight of the guard would tend to preserve the animal in an upright position, yet this weight would more than counterbalance the buoyancy which could be obtained by chambered portions no greater than those found in the specimens which are commonly met with. To ascertain the size of the chamber which would be requisite to compensate for the weight of the guard, I made the following experiment.

I fastened with gum a piece of oiled paper of a conical form in the cavity from which the chambered part had fallen out of a large Belemnite; and putting into this cone some cotton, to prevent the paper from collapsing by the pressure of the water, I found that the apparatus floated with a paper of no larger size than from some known fine specimens we may fairly conclude the outer chamber to have attained.

Thus far successful, I now resorted to a particular examination of the belemnitic shell, to acquire, from its laminar construction and muscular impressions, facts to ascertain how far they might confirm or confute my theory,—that it had sustained no change by petrifaction, but was from its first origin composed of fibrous spar.

IV. *Particular Remarks on the internal chambered Cone of the Belemnite.*

It appears that the part of the animal's body which was once contained in the outer chamber secreted a thin layer of a spathose fibrous texture, and that a thin coat resembling nacre but not iridescent, covered the fibrous spathose layer externally and internally, and cemented the whole strongly together. It is evident that the external nacreous investment of this first lamina forming the chambered cone, could not be formed by that portion of the animal which was within the cone, but was secreted by parts encompassing it. The exterior surface of the cone is, however, less smooth than the interior, and offers thereby an admirable contrivance for its adhesion to the sides of the guard; proving also, clearly, that it does not result from the same portions of the animal which form the guard, and that this was formed subsequently.

As the portion of the animal within the cone increased in size, so it enlarged its encompassing shell at the upper margin, at the same time forming a transverse concave thin lamina at a short distance from the bottom of its shell, and carrying its sides for some height upwards, thereby affixing the lamina and strengthening the sides of the conical shell. Thus an inner chamber was formed, from which the animal was completely excluded, and with which it only communicated by its siphuncle extending on one side into it. The siphuncle appears to have been encompassed by a spathose lamina connected above and below with the transverse one, and affixing laterally to the conical shell.

Each transverse septum is composed of three or four spathose laminæ, separated from each other by the investing nacreous layers just described. The sides of the upper laminæ are carried up to nearly the same point where those of the first formed laminæ terminate: each, however, successively becomes a little shorter, and thereby forms a circular rim on which the transverse lamina forming the next chamber rests. Hence there results a series of concave cups, whose edges take a conical direction and whose sides adhere to a thin encompassing conical shell, thereby strengthening the latter, and forming an assemblage of chambers, through the whole of which the siphuncle extends.

These laminæ exhibit throughout a fibrous and spathose structure, the direction of the fibres always forming radii to the curvature of the part. They are covered above and below with a nacreous investment, which being opaque or differing in colour, exhibits when the shell is dissolved in diluted acid clear traces of the animal matter forming fine pellicles. The preservation of these pellicles appears to me to afford an argument in confirmation of my views,—that the intermediate layers of fibrous spar belonged to the original texture of the shell, and are not the result of subsequent infiltration; otherwise it appears

probable that in the progress of crystallization these pellicles would have been disarranged and obliterated.

Several circumstances induce me to believe that the last or outer chamber of the conical shell could at no time have possessed any great depth; for the thin parietes of the conical shell could have acquired but little additional strength from the extension of the edges of the last septum; and had they therefore projected far beyond it, so frail a fabric would have been liable to be squeezed in by the lateral pressure of the water. Indeed, a section of a perfect specimen imbedded in its matrix, in my possession, in which the termination of the parietes of the upper chamber is distinctly to be traced running to a sharp edge, confirms this fact,—that the outer chamber was like the rest, very shallow.

The chambered shell appears also from this and several other specimens to have considerably extended above and beyond the upper extremity of the guard. Hence we may conclude that the casts of large chambers often found separate, do not indicate that the guard was of equal size. From the shell being frequently traversed by numerous septa, it acquired a considerable degree of strength and a power of resistance to the pressure of the surrounding water, whilst it aided the locomotive power of the animal by its buoyancy.

V. *Particular Remarks on the Structure of the external Guard or Sheath of the Belemnite.*

The form of the guard or sheath varies in different species. In some it is fusiform, in others conical; in some slightly elongated, in others it is of considerable length; in some it has a round, in others an elliptical circumference. Its termination is either acutely pointed, or conical; either compressed, or mamillated; and sometimes the apex is slightly aduncated. Some species have one, and others two or three longitudinal grooves. The surface of some is smooth, in others it is slightly granulated; and on some species we may trace impressions which evidently betray marks of muscles which have clasped or encompassed this part of the Belemnite, and show the impressions of branching vessels.

Some species are semitransparent, others are opaque: in the former we may observe that the guard is formed of two or three nearly equal longitudinal portions, and along the line marking their adhesion the Belemnite easily separates by a slight blow with a hammer, or by being heated and afterwards moistened with cold water. By the same means a similar organization may be discovered in the opaque ones. The edges of these longitudinal portions are irregularly waved, and adhere closely together.

A longitudinal or transverse fracture of the guard, shows that it is formed of several concentrically superposed laminæ perfectly corresponding with those in the chambered cone; each similarly formed of an arrangement of spathose fibrous crystals forming radii to its curvature, and also covered and cemented together by a very thin nacreous investment, which by being of a less pellucid appearance affords a mark which enables us to trace the thickness of each lamina.

The circumstance above stated with regard to the division of the belemnitic guard into two or three longitudinal portions, may perhaps authorise the conjecture, that its laminæ were secreted in these separate parts by two or three distinct longitudinal portions or flaps of the animal, laterally touching each other, with irregular edges from whence resulted the irregular suture.

As the animal, by its situation in the first chamber of the conical multilocular shell, cannot form the guard in any other manner than by apposition of its laminæ externally, it is rendered thereby certain that this must have been effected by portions of the animal protruding over the edge of the upper chamber, and encompassing the whole of the exterior both of the shell and the guard.

I have before expressed my opinion, that the laminæ of radiating spar interposed between the nacreous layers of the chambered portion, belong to the original organization of the shell, and had not been introduced by subsequent infiltration; and I must here repeat the same opinion with regard to the similar laminæ of the guard. If we consider the system of nacreous layers alone, abstractedly from the intervening sparry matter, the guard would exhibit a texture greatly resembling the bone of the cuttle-fish (*Sepia officinalis* Linn.); namely, a series of concentric calcareous layers, separated by very narrow intervals, and held together by transverse fibres: and such in fact is the appearance it often presents when the sparry matter is removed by partial decomposition. But I cannot persuade myself, that if the spathose substance had been subsequently introduced by infiltration into the cavernous intervals of such a structure, it would have there shot into radiating crystals, without obliterating and destroying all traces of the frail intervening plates. I think that I am able to show that such an obliteration of the internal structure has taken place (with the exception of a few cases) in the instance of echinital and crinoidal remains, which by their conversion into an uniform and peculiar modification of calcareous spar, would afford a case analogous to that of the Belemnite, should we consider the sparry state as superinduced in it.

I may mention, in support of the opinion here expressed, that the large tubular shell found in the Eastern seas, and called by Lamarck *Septaria are-*

naria, is composed of radiating crystals of carbonate of lime. This instance is important in illustration of my theory, as showing the actual existence of such a structure in the shell of a living animal.

VI. *Effects of Decomposition on the Shell of the Belemnite.*

In many shells, such as Nautili, Ammonites, and Trochi, the common calcareous outer part yields more easily to decomposition than the iridescent nacreous internal coating*. We see instances of this in the thin iridescent flattened scales of Ammonites found at Watchet, which are the remains of partly dissolved shells.

In the Belemnite, however, it appears that the nacreous portion yielded to decomposition more readily than the spathose parts.

The proofs of this are to be found in the frequent separation of the guard from the chambered cone. These parts were originally connected by nacreous matter, and it is the decay of this matter which has caused them to separate. The further process of decomposition acting on this cavity, produces a groove along the line between the two portions of the guard.

The central canal, which on breaking the Belemnite is sometimes found to traverse the axis of the guard, and which has been considered by some writers as a channel for nerves or vessels, and by others as a continuation of the siphuncle, is also to be attributed to decomposition.

There is no connexion whatever between this channel and the chambered portion, which is completely invested and surrounded by the inclosing shell. The manner of its formation appears to me to be, that the nacreous layer which is deposited between each of the spathose ones, is continued at the apex of the guard into a prolonged point, so as to reach the succeeding nacreous layer; and this substance having decayed while the spathose part remained unaltered, a continuous channel has been formed.

Decomposition also shows itself sometimes in removing the calcareous matter, cementing together the longitudinal portions of the guard, and sometimes we find that particular layers of the calcareous matter are attacked (perhaps from some peculiarity in their composition making them more liable to decay): and thus a separation takes place between the outer portion of the series of layers and those within the decayed layer. The inner portion is what at an earlier stage of growth was the whole of the belemnitic guard. The outer portion has,

* This nacre may be better calculated to resist decay, on account of its containing (according to Mr. Hatchett's experiments) 24 per cent of animal membrane, possessing properties similar to coagulated albumen. We have no means of ascertaining what proportion of such substance existed in the nacre of the Belemnite.

from such a decay, an accidental cavity, which may be distinguished from the cavity of the chambered part by its difference in form; the accidental cavity being of the form of a more elongated cone, and having also frequently a projecting point arising from matter accidentally indurated in the central canal, above noticed, as having been mistaken for the continuation of the siphuncle.

In some fragments of Belemnites, two conical cavities have been observed; one of these is undoubtedly the cavity of the chambered shell, the other has arisen from the accidental falling out of a portion of the guard.

On immersing the guard in dilute acid, we discover that animal matter intervenes in small quantity between the fibrous crystals.

If, as I have supposed, the guard was originally of a crystalline structure, it would certainly present great obstacles to decomposition. This is indeed proved by the shells of the genus Pinna; the only ones, I believe, which, having a texture resembling that of the Belemnites, are found both in a recent and a fossil state. The fossil Pinnæ found in the lower beds of the London clay at Bognor, and in the Paris beds, retain distinctly the same structure as the recent ones.

The fibrous shell so frequent in the oolite (supposed to be an oyster and described as Ostrea Trichites, but evidently from its peculiar organization belonging to a distinct genus) and the Inoceramus of the chalk, presents a fibrous and more or less crystalline texture, which in these cases no one has ever doubted to have belonged to them in their original state.

I have seen, in the collection of Richard Bright, Esq., many specimens where Belemnites had been imbedded in flint, and have been dissolved out; and in the hollows which they had occupied, are remaining siliceous casts of those spherical bodies with connecting fibres which the Rev. W. D. Conybeare has described in the 3rd volume of the Geological Transactions as resulting from the infiltration of silex into cavities formed by some boring animal. Mr. Allan has also figured these bodies in Belemnites in the Edinburgh Transactions. In Mr. Bright's specimens, some small portions of the radiating calcareous spar of the guard of the Belemnite are remaining among the connecting siliceous threads.

Von Tressau observes, as a proof of the indestructibility of the Belemnites, that those found in iron mines along with Ammonites and Nautili, have sustained no change, whilst the latter are converted into ochre.

The Belemnite in fact rarely occurs otherwise than with such a texture as may present on fracture a fibrous spathose organization; and where this has been penetrated by silex or other mineral substances, it has always, and but with only one exception, destroyed its peculiar formation.

In the Lyas and Lyas-clay, pyrites frequently enters the chambered cone, which on account of its more fragile construction it is able to attack, whilst the guard resists its operation. Sometimes we meet with the shell of the chambered cone in a semi-decomposed state, involved in pyrites, and flattened as far as it projected beyond the guard, or as far as its latest formed and adhering laminæ were unable to resist the pressure of incumbent matter. In other instances we obtain a beautiful conical pyritic cast showing marks of the rim of the concave septa (the outer shell of the cone being destroyed), and the situation of the siphuncle in a series of indentures, which from a hasty and mistaken analogy have been once considered as the spiracula of the Belemnite.

I possess a Belemnite in chert from Dantzic, which is converted into chalcedony, and where the fibrous structure of the shell is entirely destroyed. The chalcedony has assumed its own mineral figure, and has a mamillated surface in the cavity once occupied by the chambered cone. A transverse fracture shows a few concentric markings common to chalcedonic nodules.

Miss Benett of Norton House is in possession of a few specimens of Belemnites minimus, from near Warminster, (much resembling Parkinson's representation in the 3rd volume of Org. Rem. Pl. IV. fig. 14.) which have experienced the changes so often exhibited by the fossils imbedded in green-sand, and which have gradually silicified. It is owing to the kindness of that lady that I have been able to examine these Belemnites carefully. They exhibit in their present state externally a few thin conical lamellæ superimposed on each other, and adhering by transverse fibres somewhat analogous to the structure of the common cuttle-fish, and are in many instances hollow in the centre. My explanation of this structure is, that these now siliceous lamellæ have replaced the nacreous layers; and that the intervening fibrous crystalline substance, as well as the lamellæ forming once the centre of the guard, have disappeared by decomposition. Belemnites of this kind are very rare; and it is interesting that some of these show the same irregular cavities as I noticed in a calcareous specimen in Mr. Greenough's possession, similar to the one figured in Knorr (Vol. III. Supp. iv. f. fig. 8.).

Accident furnished another clue to the illustration of the cavities in the specimens referred to, ascribed to the mere dropping out of certain portions of the laminæ by decomposition. I observed on the surface of a few specimens of Belemnites from the oolite at Dundry, some circular markings, occasionally one within the other, having an irregular floriform petal-shaped and sometimes subvermicular circumference, similar to those represented in Knorr (Vol. II. part ii. Pl. I.* fig. 5.); which Walch there considers as marks occa-

sioned by worms or decomposition. On exposing one of these Belemnites to the action of nitric acid, to detect the animal gluten, I found to my surprise that these markings were a siliceous insinuation, sometimes extending in most delicate fibres between the crystals forming the laminæ. These circular figures on calcareous and siliceous shells are by no means uncommon; and I was pleased to detect them also in the silicized Belemnites in Miss Benett's collection.

VII. *Chemical Analysis of the Belemnite.*

Acton found the species of Belemnite he analysed to contain

45·55	carbonic acid
53·95	lime
40	oxide of manganese and iron
10	water and loss
100	

No alumine could be detected by succinate of ammonia. I have no doubt that the different species of Belemnites would furnish different analyses, but am at present prevented from going into these details.

On immersing the Belemnite in diluted nitric acid, I detected the interlacing animal matter exhibiting appearances similar to those in nacreous shells. A stronger acid tore the fibres asunder, coloured the solution yellow, and evolved a very pleasant smell resembling that of Cerambix moschatus. On scraping or burning the Belemnite, it evolves a smell by no means unpleasant. On exposure to fire, the crystalline laminæ lose their water of crystallization, and assume an opaque, white, fibrous, submargaritaceous appearance.

In those early periods of science in which almost every substance of singular form was supposed to possess occult medical qualities, the Belemnite was considered as a protector against several complaints. Dr. Woodward informs us, that in Gloucestershire they use it pulverized in watery affections of the eyes of the horse, by blowing it into them. It is also used internally in nephritic cases. In Prussia they use it pulverized in the dressing of wounds.

VIII. *Conjectures on the Form of the Inhabitant of the Belemnite.*

There can be no room to hesitate in agreeing with Cuvier and Lamarck, that the Belemnite belonged to the cephalopodous division of Mollusca. The identity of structure in the chambered portion with the other genera of multilocular shells is alone sufficient to prove this; and we shall presently find additional confirmation of the same fact. The cephalopodous division of Mollusca consists only of two subdivisions, nearly allied to each other in the general cir-

cumstances of their structure; namely, the Nautilacea and Sepiacea. The former are provided with multilocular shells, probably intended as an apparatus to regulate the animal's buoyancy: but of this subdivision, only one genus, the Spirula, has been examined with anatomical precision, and it therefore remains involved in much obscurity. The second subdivision, the Sepiacea, have no shell; but in lieu of it, a complex laminated calcareous mass (somewhat improperly termed bone, and well known in commerce as cuttle-fish bone,) exists in the genus Sepia, and a horny plate in the genus Loligo. The former may very possibly, like the multilocular shells, assist, by its porous and cellular structure, to render the animal more buoyant; but the latter can scarcely answer any other purpose than giving a support to the contiguous muscles. The animal of the Belemnite probably formed an intermediate class of the order, uniting the internal multilocular shell of the Spirula with the laminated calcareous mass of the Sepia, to which the belemnitic guard appears to correspond, as it is formed in a manner exactly similar; namely, by the apposition of successive laminæ, of a concentric curvature, upon each other, in successive strata: the only difference being, that in the cuttle-fish those spaces are not closed and the edges of the laminæ do not meet in a circle; whereas in the Belemnite, the parts secreting the shell, bending and closing round so as to embrace a conical surface, made the laminæ assume the same direction and curvature. From the interstices between the laminæ not having been empty, but, as I have supposed, filled with spar at the period when the animal formed the guard, I conjecture that the buoyancy of the animal must have been provided for by the chambered shell, and that the guard acted as a counterpoise to it.

With these views, I believe the inhabitant of the Belemnite to have been a Sepia-like animal, having a body of an abbreviated form partly inserted into the first chamber or aperture of the chambered cone, and connected to it by a duct extending from it to the end of the siphuncle. I further conceive, that a powerful circular muscle inclosed the chambered cone as far as the place where the laminæ of the guard encompass it; and that another muscle extended on one side over the guard for its whole length, having laterally adhering to it on each side, a muscle provided with a secreting surface and capable of encompassing the guard. This form of the animal would admit the formation of the shell of the Belemnite, and correspond with the details its organization presents.

When the animal increased in size, it formed a new septum in front of the chambered cone, adding at the same time a new rim to the cone. Hereby its shell acquired a new chamber and a greater degree of buoyancy, to counteract

which, a new spathose and nacreous lamina was secreted over the guard; an effect not capable of being produced, had the guard originally possessed a laminar cavernous organization.

I believe it will be proved by further researches, that all chambered shells are inclosed in, or capable of being covered and encompassed by, the animal; for without such a contrivance, that nice degree of buoyancy which they are intended to furnish to the animal would be destroyed by the adhesion of parasitic testacea, from which a perfect protection is thus obtained. From the size of the animal and the smallness of the outer chamber, it is clear that the inhabitant of the Belemnite could never entirely withdraw within the shell; and it appears probable that the guard, independent of its use in preserving a well-adjusted buoyancy, was also intended to furnish to the muscles an abutment and support on which they could adhere, and from which, like a fulcrum, they could receive additional strength.

The surface of the two lateral muscles which encompassed or clasped the guard, had each a distinct power of secretion, although they formed their laminæ at the same time. This accounts for the sutures which separate the guard into two longitudinal portions. These muscles, in some specimens appear not to have increased in proportion to the laminæ they encompassed, and therefore, when the guard greatly enlarged, to have been unable to secrete other laminæ completely surrounding the former. Hence arises sometimes a groove on one side, frequently in old specimens displaying the shortening of the laminæ as they accumulated and as the edges of the muscles were withdrawn.

In some species the muscles appear to fold together near the apex, and form two or three grooves in this part; while in others they lap over the apex and form a mamillar termination. In very perfect specimens we may observe in some species a longitudinal slit in the guard where it adheres to the chambered cone, evidently also arising from the causes cited before. On the guard of such specimens we may distinctly trace impressions of the branching blood-vessels in each of the two longitudinal muscles; which furnishes, in my opinion, *a most satisfactory evidence that the guard was really enveloped by them in the manner in which I have stated.*

Description of the Species.

In endeavouring to fix specific characters to the various Belemnites that have fallen under my observation, and which I have considered as distinct species, I ought to state that they are chiefly derived from that part which I have called

the guard. I must however acknowledge the insufficiency of this part to yield distinctions which may secure us from all error. It is obvious how much a form is liable to be changed where it results from the continual superpositions of fresh laminæ, which if not regularly and conformably secreted, produce not unfrequently considerable deformity and deviations.

Sp. 1. Belemnites abbreviatus (nobis). Pl. VII. fig. 9, 10.

Sp. Ch. Guard short in proportion to the length of the chambered cone, tapering to a conical and very slightly curved point, compressed on two sides.

Syn. and Ref. Parkinson's Org. Rem. vol. iii. Pl. VIII. fig. 8 & 15.

Locality. Weymouth, Dundry.

Stratum. Inferior oolite.

This species grows large, the chambered cone has generally a lateral position, in consequence of the accumulation of laminæ being on one side more than on the other; hence its apex forms frequently a slight curve. The guard is also thicker on one side than the other; hence somewhat suboval, and not unfrequently finely striated longitudinally.

Sp. 2. Belemnites aduncatus (nobis). Pl. VIII. fig. 6, 7, 8.

Sp. Ch. Guard very smooth yet sometimes finely striated, cylindric, terminating in an aduncated apex marked with four or five ridges, the sulci between which are sometimes slightly tuberculated.

Locality. Weymouth, Lyme.

Stratum. Lyas and lyas clay.

This species is considerably more slender than the former, but otherwise resembles it.

Sp. 3. Belemnites sulcatus (nobis). Pl. VIII. fig. 3, 4, 5.

Sp. Ch. Guard subcylindrical, elongated, having a longitudinal sulcus, and terminating in an acute apex.

Syn. and Ref. Plott's Hist. of Oxford, Tab. III. fig. 6.

Locality. Dundry, near Oxford.

Stratum. Inferior oolite.

This species has sometimes a considerable thickness, when the sulcus is very distinctly marked, evidently occasioned by the upper laminæ not completely surrounding the guard.

Sp. 4. Belemnites elongatus (nobis). Pl. VII. fig. 6, 7, 8.

Sp. Ch. Guard slender, tapering to a conical point.

Syn. and Ref. Platt in Phil. Trans. vol. liv. for 1764, and in the Abridgment of ditto, vol. xii. Pl. III. fig. 8.

Locality. Lyme in Dorsetshire.

Stratum. Lyas and lyas-clay.

This is a slender species of a dark brown colour, generally showing very distinctly the organization of its guard in the superposition of its laminæ.

Sp. 5. Belemnites longissimus (nobis). Pl. VIII. fig. 1, 2.

Sp. Ch. Guard very thin, long, smooth and terminating in a conic point.

Locality. Lyme in Dorsetshire.

Stratum. Lyas and lyas-clay.

This species is very remarkable on account of its slender form, generally of a yellow brown colour and more than usually opaque.

Sp. 6. Belemnites acutus. Pl. VIII. fig. 9.

Sp. Ch. Guard conical, terminating in an acute point.

Syn. and Ref. Luid. Tab. XXV. fig. 1683?

Sp. 7. Belemnites tripartitus. Pl. VIII. fig. 10, 11, 12, 13.

Sp. Ch. The guard is formed of three longitudinal portions, showing near the apex three distinct longitudinal ridges.

Syn. and Ref. Von Schlotheim Petrefactenkunde, vol. i.

Sp. 8. Belemnites ellipticus (nobis). Pl. VIII. fig. 14, 15, 16, 17.

Sp. Ch. Guard opaque, grayish brown, much elongated, elliptical, terminating in a mucronated point.

Syn. and Ref. Knorr, Monum. vol. iii. sup. IV. fig. 3 & 4.
Klein, Tub. Mar. Tab. IX. fig. 3 & 4.

Locality. Iron mines at Fuerslenberg (Knorr), Dundry.

Stratum. Inferior oolite.

It is a very large and long species, almost opaque and of a pale yellow brown colour. The guard in an early state of growth is generally round, as may be seen in transverse sections, but becomes subsequently, by an apposition of laminæ of irregular thickness, of an elliptical form.

Var. α. The guard less elliptical, terminating in a conical point.

Locality. Dundry.

Stratum. Inferior oolite.

Probably only young specimens of the former.

Sp. 9. Belemnites electrinus (nobis). Pl. VIII. fig. 18, 19, 20, 21.

Sp. Ch. Guard amber-colour, nearly transparent, cylindrical, lower end conical, with a mamillated point. In perfect specimens, where the guard adheres to the chambered cone, a longitudinal groove in the centre. On the surface generally traces of the impression occasioned by two longitudinal branching blood-vessels.

Syn. and Ref. Park. Org. Rem. vol. iii. Pl. VIII. fig. 12; and a bouldered fragment, fig. 10.
Faujas St. Fond, Hist. Nat. de la Mont. de St. Pierre, Pl. XXXII. fig. 3.
Mantell's Geol. of Sussex, Tab. XVI. f. 1.

Locality. Salisbury, Isle of Moen, and Rügen, Berwick near Hindon, Brighton, Lewes. Bouldered fragments in the sands of the north of Prussia.

Strata. In the Chalk formations. The bouldered fragments in the sands of Prussia are probably derived from displaced beds of chalk formerly in connexion with the Isle of Moen and Rügen.

The mamillated point of this species being formed of more nacreous matter than the rest of the guard, becoming as the guard increases in length its axis, produces on decomposition the central canal described before.

Sp. 10. Belemnites fusiformis (nobis). Pl. VIII. fig. 22. Pl. IX. fig. 5, 7.

Sp. Ch. Guard contracted in diameter below the point of the chambered cone, swelling out again and terminating in an acute point. A deep sulcus extends for nearly the whole length of the enlarged portion of the guard.

Syn. and Ref. Luid, Tab. XXV. fig. 1705.
Park. Org. Rem. vol. iii. Pl. VIII. fig. 13.
Hibolithus hastatus. De Montf. vol. i. p. 587.
Porodragus restitutus. De Montf. vol. i. p. 591.

Locality. Stonesfield, the environs of Gap.

Stratum. Stonefield slate.

The laminæ forming the shell of this species are nearly opaque, and of a dark gray brown colour. The porous appearance of the guard which De Montford has described as a character of the genus Porodragus, appears to be the result of decomposition.

Sp. 11. Belemnites minimus. Pl. IX. fig. 6.

Sp. Ch. Guard subfusiform, corneous, semitransparent, showing two ridges, point conical, convex, submamillated.

Syn. and Ref. Belemnites minimus. List. Hist. Ang., p. 228. fig. 32.
Belemnites Listeri. Mantell's Geol. of Sussex.

Locality. Folkstone, Ringmer, Sussex, Surry, Kent, Cambridgeshire, Stutgard? in Prussia.

Of this species I have not yet seen the chambered cone. The guard shows frequently the central canal formed by decomposition, as also impressions of the two longitudinal vessels. The nacreous laminæ have sometimes a subiridescent colour.

VI.—*Observations on the Genus Actinocamax.*

By Mr. J. S. MILLER, A.L.S., &c.

[Read May 2d, 1823.]

HAVING lately had the honour of submitting to the Geologial Society some observations on the Belemnites, I proceed to lay before them the result of my inquiries with regard to another class of organic remains nearly connected with these;—namely, those spathose bodies which resemble the belemnitic guard in general appearance, but are distinguished from it by presenting, instead of the terminal conical cavity intended for the reception of the chambered shell, a protruding and convex base; they are of familiar occurrence in the chalky strata.

These bodies have been considered by some writers as true Belemnites, by others as Echinital spines. The object of the following communication is to show, by a minute comparison of their structure with that of these bodies,

1st, That they have no analogy with Echinital spines.

2dly, That they present very strong analogies in the minutest points of their internal structure, &c., with the guards of the Belemnites; but yet having evidently never possessed a chambered shell, must be separated from them.

3rdly, That they were probably however, like the Belemnites, appendages of some distinct family of the same order of Cephalopodous Mollusca, possessing the same position and use with the bone of the Sepia and guard of the Belemnite; exhibiting a new link in the series of the appendages peculiar to Lamarck's third division of this order.

Genus. ACTINOCAMAX.

Gen. Char. A club-shaped spathose concretion, consisting of two nearly equal longitudinal adhering portions. Apex pointed; base a convex but obtuse cone. The whole formed of a series of enveloping fibrous laminæ.

Animal unknown: but as these fossils occur in the strata which contain the remains of marine animals, we may infer that it also was an inhabitant of the sea.

I have derived the name I have given to these remains from *ακτις* (radius) and *καμαξ* (sudes), in allusion to its radiated fracture and the resemblance of its form to the stake-like Echinital spines. The details necessary for the illustration of the genus are embodied in the observations on the following species.

Species 1. Actinocamax *verus*. Pl. IX. fig. 17.

Spec. Char. A club-shaped spathose semitransparent horn-coloured concretion; base convex, obtuse, conical; apex submamillar. Sides depressed towards the lower end, showing two longitudinal, towards the apex branching, impressions of blood-vessels.

Syn. and Ref. An Echinital spine of an uncommon character, bearing a resemblance to the Belemnite. (Parkinson's Organic Remains, vol. iii. Pl. IV. fig. 19.)

Strata. Chalk, and sometimes inclosed in the flints imbedded in it.

Locality. Kent, Wiltshire, Sussex.

Observations.

Soon after my investigation of the Belemnite, a series of specimens of this species came into my possession; and I was astonished with the great resemblance they bore to the guard of the Belemnite in numerous respects, although in general form slightly resembling the spines of Cidarites imperialis. This resemblance induced Mr. Parkinson and some other writers on organic remains to consider them as being true spines belonging to fossil Echini. In order to examine more fully into the foundation on which this opinion rested, and guard against those deceptions into which a resemblance of general form may so easily betray the inquirer in this branch of natural history, I commenced by a minute examination of the internal structure of the Echinital spines in my possession, as well those most nearly resembling the Actinocamax, as others possessing a different form.

All Echinital spines I have been able to examine, present externally a longitudinally striated or tuberculated surface. Near the base they have a more or less finely striated rim, destined for the adhesion of muscular fibres, connecting the spine to the muscular epidermis covering the plates of the shell of the Echinus.

A transverse or longitudinal section of recent spines shows that their centre is occupied by a minutely cellular calcareous substance, not unlike that (in miniature) which occupies the centre of bones of Mammalia; from this proceed laminæ, to the circumference, at a greater or less distance from each other,

forming, in a transverse section, an elegant radiated ring around it. These laminæ are united together by longitudinal, circular, and horizontal laminæ, giving this part some resemblance to the organization of a Madrepore. The envelope of this organization externally, as stated before, is longitudinally striated or tuberculated. In the fossil specimens, the spines always show an uniform substance of carbonate of lime, having a regular fracture with the angles of the primitive rhomboid; and it is not a little remarkable, that in all the calcareous fossils belonging to the Radiata, whether Crinoidea, Asteriæ, or Echini, the state is similar; they are always composed of a crystalline carbonate of lime. Only in one instance have I seen a spine imbedded in flint, with the central portion penetrated by the siliceous fluid and changed into silex, whilst the radiating portion was decomposed, thus leaving a space between the siliceous nucleus and the impression of the exterior surface in the flint.

It is unnecessary here to enter into details of the mode in which Echinital spines grow or increase in size;—this I reserve for some general views on the organization of the Echinus. But their structure, as far as detailed here, proves evidently that it differs materially from that of the Belemnite, and that it differs equally from that of the Actinocamax, as the following statement will show.

The Actinocamax verus is, like the guard of the Belemnite, formed of superposed laminæ of fibrous crystals agglutinated and covered by a thin nacreous investment, nearly corresponding in colour and transparency to it. It loses also its colour and becomes of an opaque white on decomposition, like the guard of the Belemnite under the same circumstances. This has enabled me to ascertain (since in both instances the nacreous matter first yields to decomposition) that in the Actinocamax, as in the Belemnite, an axis of nacreous matter has existed, which by its decomposition has left a central tubular cavity exactly resembling that formerly noticed in the Belemnites electricus. The submamillar apex of Actinocamax verus resembles that of the last-cited Belemnite, and the fibrous crystals assuming in both instances a transverse direction conformable to the curvature of the laminæ, render the apex equally liable to decomposition, and to drop out in a conical form. The Actinocamax on holding it against the light shows that, like the belemnitic guard, it is formed of two longitudinal portions, uniting by irregular edges, and separating easily on fracture; thereby demonstrating that in both instances the nacreous cement is less firm than the body itself.

The lower end shows the truncated edges of all the laminæ forming the club-like concretions of the Actinocamax; but, contrary to what we observe in the Belemnite, the exterior laminæ do not project in regular succession above the

interior ones, so as to inclose a conical cavity for the reception of the chambered shell; but, following an inverted arrangement, permit the interior laminæ to rise in succession above them; so that the centre, instead of presenting a deep conic cavity, becomes convex, forming a protruding cone of which the vertical angle is about 45. This is an excellent proof of the non-existence at any time of a chambered cone in this place; since the structure described, not only affords no traces of a cavity fitted for its reception, but is altogether of an opposite character. From the centre elevation of the base to the circumference, radiating ridges extend, widening as they reach it, forming by intersecting the edges of the enveloping laminæ a subtubercular surface, well adapted for adhesion to an animal substance.

Along each of the two flattened sides is a groove, branching as it approaches the apex,—the evident impression of blood-vessels: in all other parts the surface is smooth, and not striated as in the Echinital spines, or provided with a ring near the base, which would essentially serve for the adhesion of a radiating muscle, and must therefore have been possessed by it had it been an Echinital spine.

The above observations demonstrate, that the resemblances between the Actinocamax and the belemnitic guard are not merely general and external, but extend to the minutest points of internal structure; and that both, particularly in regard to Belemnites electricus, present the very essential and remarkable fact, that similar impressions of ramifying vessels may be traced on their outer surface.

These analogies seem too many and too great to admit any other explanation, than that both substances have once formed the analogous parts of animals belonging to the same great natural order; while the important difference, —that one of these bodies has been provided with an internal chambered shell, and the other cannot be supposed ever to have possessed a similar appendage, equally proves them to have appertained to different genera, or perhaps even to different families of that order.

What that order was, is a question in which we have analogy only to guide us, the whole families of Belemnite and Actinocamax having long vanished from the actual Systema Naturæ, or at least having hitherto escaped our researches, and being known only from the preservation of their more solid parts in the strata of the earth.

These analogies, however, are such as to afford probable evidence of a very high degree; and the tendency of that evidence is, as we have before seen, and as is now universally admitted with regard to the Belemnite, to rank it as the appendage of a family of Cephalopodous Mollusca, enveloped by the animal

as the lamellar bone is by the Sepia, and the chambered shell by the Spirula and Nautilus. The chambered shell of the latter class has a structure not altogether dissimilar to that of the lamellar Sepiaceous bone.

The observations now given on the Actinocamax appear to extend the application of these analogies to that genus also. It appears to represent the belemnitic guard destitute of its chambered shell: and if the analogy between this part and the lamellar bone of the Sepia shall appear well founded, the Actinocamax will furnish a beautiful link connecting the Sepiaceous Cephalopoda with the multilocular (the Sepiaria with the Polythalama) of Lamarck: and we shall have a regular series of these animals, arranging them according to their concretions or appendages as follows.

A. Cephalopoda with a horny lamina. *Loligo.*

B. Cephalopoda with a concretion composed of many concentric lamellæ (improperly called bone) adhering to each other by transverse laminæ placed at intervals, the curve of these lamellæ forming only a portion of a circle. *Sepia.*

C. Cephalopoda with a concretion or appendage consisting of similar lamellæ enveloping or embracing a complete circle: intervals of the lamellæ filled with radiating spar secreted at the same time. *Actinocamax.*

D. Cephalopoda with a similar appendage and a small multilocular shell. *Belemnites.*

E. Cephalopoda with a multilocular shell and no lamellar appendage. *Orthocera, Nautilus, &c.*

Upon this view, the Belemnite forms the centre of the series, uniting the lamellar appendage and the multilocular shell; while the extremes on the one hand present the appendage only, and on the other the multilocular only.

I conclude, therefore, that the animal of the Actinocamax appears to have belonged to the Cephalopoda sepiacea, and its appendage or concretion to have been inclosed within two muscular parts of the animal which formed the two longitudinal portions, and left on their surface the impressions of the blood-vessels passing through the muscular integuments immediately under the secreting epidermis.

VII.—*On the Geology of Rio de Janeiro.*

By Alexander CALDCLEUGH, Esq. M.G.S.

[Read 6th June, 1823.]

THE specimens which I have now the honour of presenting to the Geological Society were collected in the neighbourhood of Rio de Janeiro, a spot so long celebrated for the beauty of its surrounding scenery. The Bay running in the direction of north and south, and extending nearly thirty miles into the interior, stands perhaps unrivalled, whether viewed as a resort for shipping, or as merely affording a fit subject for the painter. It is surrounded by conical hills, which in one instance only (the Corcovado) exceed nine hundred or a thousand feet in height, and preserve the rounded character of gneiss, which is peculiar to this rock even in Europe, where the agents of destruction are feeble compared with those of a tropical country. Many of these hills are perfectly bare, while others are clothed to their summits with the most luxuriant vegetation. In some spots they rise abruptly from the sea, in others a small intermediate space is left. Wherever any soil is deposited by the heavy periodical rains, a thick plica of vegetation springs up, which in several instances prevents an examination of the subjacent strata.

The alluvial soil is mostly of a yellow or red colour; the latter variety is frequently washed by the children of the place for the minute portion of gold which it is known to contain. In making any excavation through the loose soil on the surface, regular layers of crystals of feldspar and pieces of quartz are met with, and with no appearance of having been transported thither. I am inclined to suppose that much of the superficial soil proceeded from a decomposition *in situ*, rather than from any washing down from the hills. On the shore the sand is of a brilliant white colour, and I think there are appearances to justify the idea that the sea has retired from this part of the coast.

The district which has fallen under my examination is confined to the immediate neighbourhood of the city of Rio de Janeiro, situate on the left or west side of the harbour.

The substance of which the mass of the mountains is composed, is gneiss; granite in no instance constitutes a distinct formation. The numerous quar-

ries close to the city afford great varieties of the former rock. Although its fitness as a building-stone varies considerably, it did not appear that a preference existed in favour of any particular quarry. Proximity seemed the main object. These excavations presented favourable opportunities for observing the stratification.

The leading direction of the gneiss appeared to be N.N.W. or N.W., and the dip varied considerably; in one case it was as much as 46°, in others merely a gentle inclination. The strata in one quarry were disturbed and contorted in a most singular manner without the disturbing cause being apparent.

This gneiss formation is all more or less intersected by granite veins, varying in thickness from two or three feet to as many inches. Some of the veins were stained with oxide of iron which had extended to some distance in the walls of the mass of gneiss. There was nothing to lead to a supposition that they were formed anterior or posterior to the mass which they intersected. From the mutual intersection of the crystallization, one would be rather led to infer, at least in some instances, that they were contemporaneous.

The only superjacent beds I met with were one of greenstone near the Valongo, and one of clay iron-stone near the Queen's House. The gneiss, although in some spots resembling a micaceous slate, speedily recovered its former aspect.

The greenstone bed in the gneiss at the Valongo was about twelve feet thick, dipping 35° in the direction of S.S.E., the rock on which it rested having a slight dip to the N.W. This bed is of inconsiderable extent, and is formed of globular distinct concretions, which on being struck with the hammer separated in successive coatings abounding in oxide of iron.

The clay iron stone rested on the gneiss in very considerable thickness, but the nature of the ground and the proximity of the Queen's residence prevented a complete examination*.

The elevated peak called the Corcovado is situate on the Botafogo side of the city, and rises 2100 English feet above the level of the sea. The summit, composed of coarse porphyritic gneiss, of a hardness superior to that forming the mass of the hills below, is intersected by veins of quartz and felspar†.

In the gneiss of Rio de Janeiro, a great proportion of which may be termed porphyritic, the beauty and variety of the felspar is very striking. Some of the specimens of this mineral even approach to the moonstone of Ceylon, and others would no doubt furnish excellent kaolin. The decomposing variety is used by the lapidaries of the city to give a polish to amethysts. In

* The specimen, No. 37, is from this bed.

† The large macle of felspar, No. 34, is from this locality.

some of the beds of gneiss near the sea shore, the crystals of felspar project considerably, and appear to have alone withstood the action of the elements. Some of the masses fallen into the sea appear perfectly fresh until on attempting to stand upon them, the foot sinks into a mass of clay. The felspar is mostly in macled crystals.

A large proportion of the quartz met with in the neighbourhood of Rio de Janeiro, is of that variety termed slaty and ferruginous. It is by no means unusual to meet large boulders containing beautiful crystals of dark brown mica, of the primitive form.

The specimen of granite from a drusy vein in gneiss at the Valongo contains mica and quartz distinctly crystallized.

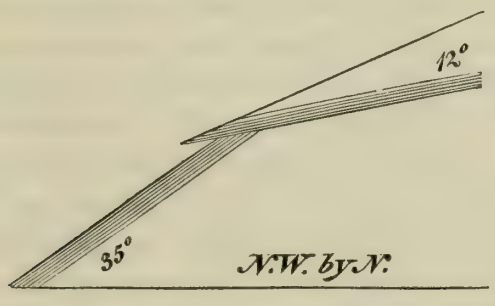
The simple minerals in the gneiss in this neighbourhood are by no means abundant. I met with the following:

Hornblende.
Yellow carbonate of lime, disseminated.
Phosphate of lime, amorphous of a deep bottle green.
The crystallized variety of the foregoing (Apatite).
Garnets, all of some tinge of red, and varying considerably in size.
Sulphuret of iron, abundant in the quarry of St. Cristovan.
Sulphuret of arsenic.
Chlorite, disseminated and lamellar.

With the exception of the garnet, which is more abundant in the gneiss, the other minerals were all taken from granite veins.

In Europe so large a district of gneiss would have afforded in all probability metalliferous beds or veins of considerable richness; but in Brazil it is only after leaving this formation, and falling in with the slates of the upper country, that any ores of consequence are to be discovered.

The following figure represents a case of frequent occurrence, of a bed of gneiss placed unconformably to those of the same rock on which it lies.



It often happens under these circumstances, that from the decomposition of the lower bed a hollow is formed by the overhanging of the upper; and I ob-

tained from such a situation, the specimens of siliceous stalactite which are now sent to the Society.

At the point of junction of the two beds of gneiss these siliceous stalactites are in great abundance.

The absence of hot springs makes the occurrence of these stalactites of very considerable interest; and I cannot avoid offering an hypothesis to explain their formation. In Brazil there is constantly a trickling of water down the bare sides of the hills, which from evident causes acquires a very considerable increase of temperature. From having crawled through these little rills on my hands and knees, I can give a pretty correct idea of their temperature, which often reaches 140° or 150° of Fahrenheit. This warm water descending on decomposing strata of gneiss, such as is the case with that from which these specimens are taken, seizes the potash of the felspar, and then acts upon the quartz; and the water evaporating, deposits the silex in the form of a stalactite. Some of the hot springs or geysers of Iceland, which form the stalactite, do not reach the point of boiling; and perhaps the quantity of silex dissolved, (the inverse of what is shown to be the case with carbonate of lime,) may in a great measure depend on the temperature of the alkaline solvent. I do not know whether the presence of potash in these specimens confirms this conjecture. In some specimens the points are perfectly opaque, but the base puts on a hornstone appearance.

With the exception of the specimens from warm springs, recent siliceous formations are comparatively scarce, but by no means unknown. If, however, the more frequent occurrence of siliceous stalactite is to be looked for, it may probably be in warm countries, where the agents of destruction and reproduction are more active than in the colder climates of Europe.

VIII.—*On a recent Formation of Freshwater Limestone in Forfarshire, and on some recent Deposits of Freshwater Marl; with a Comparison of recent with ancient Freshwater Formations; and an Appendix on the Gyrogonite or Seed-vessel of the Chara.*

By Charles LYELL, Esq., F.R., L., and G. S.S.

[Read December 17th, 1824, and January 7th, 1825.]

THE freshwater limestone which it is now my chief object to describe, differs considerably in the circumstances under which it occurs, from any similar production that has yet been noticed. In order that these circumstances may be fully understood, I shall give a brief geological sketch of that part of the county of Forfar in which the limestone has been discovered.

The county may be regarded as divided into three principal districts; that of the Grampians, that of Strathmore, and that of the Sidlaw Hills. The granite of the Grampians skirts the northern frontiers of the county, and is followed to the south by gneiss, mica-slate, clay-slate, and greywacké, each of these formations in succession occupying a tract of considerable extent, and each observing a north-east and south-west direction. Immediately on the clay-slate rests a series of strata consisting of red and green shale, of gray micaceous and slightly calcareous sandstone, and of red schistose sandstone, this series being subject in all its parts to be interfered with by rocks of the Trap family. This, which I shall call the series of inferior sandstone, has not yet been ascertained to contain organic remains; but in other leading respects it resembles that assemblage of strata which in England, and particularly in the counties of Hereford, Gloucester, and Monmouth, is so intimately connected with transition limestone. The inferior sandstone dips beneath the old red-sandstone-conglomerate which flanks the Grampians, and emerges again on the south side of the valley of Strathmore, there forming the Sidlaw Chain.

The strata in that chain are disposed saddle-wise; and along the axis or anticlinal line of the saddle, which runs north-east and south-west, the oldest members of the inferior sandstone series are displayed, lying almost horizon-

tally; the newer members of the same series dip away from the axis on either side, with an inclination constantly increasing as they recede from it*.

The eastern part of the great valley of Strathmore is composed entirely of old red sandstone. The strata are disposed in a trough, those on the northern side of the anticlinal line of the trough dipping rapidly to the south, and occupying, consequently, a narrower space than the corresponding strata on the southern side, which dip more gradually in an opposite direction. The lowest stratum of the sandstone is a conglomerate, the outcrop of which forms a range of low hills on either side of Strathmore; one range, to which the Alyth hills belong, flanking the Grampians; the other, which comprehends the hills of Finhaven, flanking the Sidlaw. Above the conglomerate is a series of red-sandstone strata, which yield an excellent freestone; and above these are some very argillaceous beds, of a deep ferruginous-red colour, provincially termed "calm."

These two last divisions of the old red-sandstone, which generally occupy the centre of Strathmore, are often buried beneath vast deposits of gravel, the debris of the various primitive rocks which compose the Grampians, and of the sandstone strata on which the gravel immediately reposes. This debris is of ancient date, and by Professor Buckland would be called "*diluvium*," a term by which I shall speak of it in the sequel.

One of the most considerable of these accumulations is in the vicinity of the Bakie Loch. Its southern boundary is the river Dean, and its northern the road leading from the bridge of Ruthven to Lindertis, and onwards in the direction of Kirriemuir. This diluvial district derives a singular character from the confused manner in which the debris is heaped up. The eye is struck with the absence of that regular system of valleys which it is accustomed to trace in hilly tracts. Large hillocks are seen of sand and gravel, irregularly scattered on all sides, and swampy hollows between these hillocks, from which the waters have no natural drainage. Some of these hollows are filled by peat; others are occupied by lakes, among which is the Bakie Loch.

This loch is situated in the parish of Ayrly, about 9 miles due west of Forfar, about 4 miles north-east of Meigle, and about the same distance north-west of Glammis. A castle of the same name, of which the foundations only now remain, formerly stood on the western bank. The loch once extended

* The strata dip with great regularity to the south-east along the coast from Dundee to the Red Head; but Mr. Blackadder has long remarked (and I have had opportunities of confirming the fact), that the inclination is to the south-west on proceeding further westwards. This change takes place suddenly to the west of the meridian of Dundee.

over about 200 English acres; and to this area the beds of peat and marl, which occupy its former site, are now confined. It was partially drained about 70 years ago, and has subsequently, at various intervals, been further reduced in level (see Stat. Account of Scot. vol. ii. p. 212). About 7 years ago it was more completely drained, having for a long time previous been reduced to the state of a peat-moss.

The ancient banks consist entirely of diluvium, which from the structure of the country must extend also beneath the lake: from the thickness, however, of the more recent deposits, this debris has not yet been reached in cutting the deepest drains through the ancient bed of the Bakie. The retention of water in the hollow of the lake is owing to the clay, which is generally blended with the sand and gravel of the diluvium of Strathmore. This mixture, so impervious to water, is provincially termed "*mortar.*" It is well displayed in a section at Marcus, below the Bridge of Tannadice, on the South Esk; and was found to constitute the bars of the two great marl-lochs of Logie and Balgavies, when the former was completely, and the latter partially, drained.

Of late years the Bakie has yielded a supply of marl of much importance to the agriculture of the neighbouring district. This deposit is very variable in thickness in different parts of the lake; and as it has been worked irregularly, at intervals, by different labourers, it is now very difficult to obtain accurate information concerning the manner in which it occurs distributed. The following, however, may be considered as a pretty correct section of the beds, beginning with the uppermost.

	Thickness.
1. Peat, containing trees	from 1 to 2 feet
2. Shell-marl, containing, in parts, tufaceous limestone provincially termed "*rock-marl*"	1 — 16
3. Quick-sand, without pebbles, cemented together, in some places, by carbonate of lime	0 — 2
4. Shell-marl of good quality for agriculture. Almost every trace of shell is often obliterated	1 — 2
5. Fine sand, without pebbles, like No. 3. not sunk through in cutting the great drain, and therefore at least	9

This bed of sand, on the borders of the lake, is seen to rest upon the diluvium.

The following is the section which I saw exposed to the south of the great spring, while the marl was being cast, in October 1824.

	Thickness.
1. Peat	inconsiderable.
2. Shell-marl	9 feet.
3. Quick-sand	from 2 to 3
4. Shell-marl	1 — 2
5. Quick-sand, like No. 3.	unknown.

Near the old castle, marl of pure quality has been sunk through of the remarkable thickness of more than 16 feet. In the Loch of Restennet it is said to be equally thick.

The tufaceous limestone or rock-marl is limited to the vicinity of the springs, which occur distributed irregularly over the lake. A small part of it only can ever be examined; since those spots where it is abundant, from its impeding the casting of the shell-marl, are avoided. It belongs to the upper or great bed, if exclusively belonging to either of the two beds of marl; but this point is uncertain, since in the two following sections, which are the only ones that I succeeded in obtaining, the sand No. 3, which usually divides the upper bed of marl from the lower, is wanting.

Section immediately to the South of the great Spring.

	Thickness. Ft.	In.
1. Tufaceous limestone or rock-marl, forming a solid continuous stratum, extending on the surface over many square yards	1	2
2. Soft marl, containing throughout its whole substance many flattened concretionary masses of tufaceous limestone or rock-marl	2	4
3. Sand, without pebbles, bored to the depth of	2	2

Section on the side of the great Drain near the great Spring.

	Thickness. Ft.	In.
1. Soft-marl	1	0
2. Ditto, sometimes sandy with concretions of tufaceous limestone or rock-marl . . .	1	6
3. Loose sand	unknown.	

The shell-marl of the Bakie is white, with a very slight tinge of yellow, and is less mixed with vegetable matter than the marl of other neighbouring lakes; a consequence, probably, of there not being any stream, however small, which enters the lake, and by which foreign matters can be drifted into it*. It rarely consists of distinguishable shelly matter in large proportion; and in some parts of the lake, particularly in the vicinity of the springs, is a pure calcareous substance, free from every trace of organization. This latter variety of marl is unctuous when in a moist state; and when dried, it much resembles the softest varieties of chalk, though somewhat more loose and pulverulent.

The limestone or rock-marl has the same yellowish tint as the shell-marl.

* When a stream enters a lake, peat is drifted in, and deposited at the bottom. Thus in the Loch of Forfar, from which shell-marl is annually dredged, the surface is found covered with a thin fluid peat, which it is necessary to begin by removing.

It consists almost wholly of carbonate of lime; is extremely hard and compact, and when broken and viewed with a lens, is in parts decidedly crystalline. Its fracture is fine-grained, slightly splintery, approaching to even when viewed in the great, but uneven when viewed in the small. Many blocks of this substance, which have been exposed for several years, are found to have resisted entirely the action of the frost and the weather. Some of these, which have been built round the great spring, measure $2\frac{1}{2}$ feet in length, and above 1 foot in breadth and thickness. Some masses present a wavy mamillar surface, and resemble stalagmite. Some few have a lamellar texture.

The rock is traversed vertically by numerous irregular tubular cavities, the sides of which are in general fretted with minute stems and fibres of fossilized vegetables in a very friable state, apparently Charæ. Since clusters of these vegetables sometimes occupy the centres of the cavities, they possibly may have occasioned the cavities themselves. I shall notice these cavities more particularly in the sequel, when comparing the tufaceous limestone or rock-marl of the Bakie with ancient freshwater limestone. The flattened concretions of limestone sometimes consist almost entirely of aggregations of fossilized stems of Charæ, and in respect of their general composition they do not differ materially from the continuous stratum.

Organic Remains of the Marl.

Quadrupeds.—The remains of quadrupeds are frequently met with in the shell-marl of this lake; but in the tufaceous limestone or rock-marl I have not yet discovered them. The present proprietor has shown me the horns of stags and bulls of large size, taken out of the marl within his memory; and in the Statistical Account of Scotland, vol. ii. p. 213, the horns of a stag, weighing 24 pounds, and the tusk of a wild boar, are mentioned as having been found in the Bakie and presented to the Society of Antiquaries.

The remains of quadrupeds have also been found in the marl of the neighbouring Loch of Kinnordy, and have been dredged up in some of the marl-lochs that have not been drained, from the depth of 16 feet below the surface of the water.

It is by no means obvious in what manner these animals, which are active in swimming, were lost in lakes of such moderate dimensions as those in question, and became buried in the marl. Mr. Blackadder has suggested, with great appearance of probability, that they were drowned in passing over the lake when frozen, at those points where, owing to the springs, the ice was weakest, and where, as I have previously stated, the marl is produced in the greatest quantity. He has remarked also, that in the winter the marshy borders

of the lakes are rendered peculiarly enticing to herbivorous animals; since when the country is buried under snow, the aquatic grasses in such situations continue for a long time to present a green surface*.

Crustacea.—The *Cypris ornata* (Lamarck) occurs in the limestone, and is the only crustaceous animal that the marly deposits of the Bakie have yet afforded me. The valves only remain; and these, which are semi-calcareous in the living animal, in the marl occur completely fossilized, like the stems of Charæ which accompany them. This Cypris is not uncommon in the lakes and ponds of England. Another species, the *Cypris Faba,* is mentioned by Monsieur Brongniart as occurring in an ancient freshwater formation in the department of the Allier, in the south-east of France. (Oss. Foss. 2d edit. tom. ii. p. 536.)

Testacea.—The following shells are not uncommon in the limestone or rock-marl, and belong (particularly the three first) to the same species which are most abundant in the shell-marl of Forfarshire.

Names of Montagu.	*Names of Lamarck.*
1. Helix peregra	Limnea peregra.
2. Turbo fontinalis	Valvata fontinalis.
3. Cardium lacustre	Cyclas lacustris.
4. Helix contorta	Planorbis contortus.
5. Patella lacustris	Ancylus lacustris.

Many of these shells are very minute, and must have belonged to very young individuals: indeed we rarely meet with full-grown shells in the marl of this country. The shells in the limestone are sometimes empty, but are generally filled with the substance of the matrix, and when taken out, leave a smooth polished mould, as in the older limestones. Sometimes the shells contain crystals of carbonate of lime.

* It is probably in the sites of ancient lakes that the remains of the Irish elk are found, both in Ireland and in that part of the Isle of Man called the Curragh; since they occur in beds of marl covered by peat. The author of the article on Organic Remains in the Edinburgh Encyclopedia, states that in the Curragh the elks lie within a small space, as if assembled in a herd; that their skeletons are generally entire, in an erect position, and (as the people of the country who dig them out affirm) having the nose elevated as high as possible. The position of the skeletons is the same that we should expect to observe in animals which had sunk in boggy ground, endeavouring to keep the nose aloft as long as possible. Cattle which have thus sunk in the bogs of Forfarshire are said to be *laired*, from the old verb *lair*, to mire. The skeletons of the great mastodon found in boggy gound near the great Osage river in Louisiana are found in a vertical position, as if they had sunk in the bog [Cuvier, Oss. Foss. 2d edit. tom. i. p. 222]. And a skeleton of the same animal lately discovered in New Jersey, about 40 miles to the south of New York, was found in the same position in a stratum of black earth, the head being on a level with the surface. [Ann. of Lyc. New York, vol. i. p. 143.]

Plants.—Among the vegetable remains of the limestone is one which proves to be strictly analogous to the Gyrogonite of the ancient freshwater formations, and which therefore is a subject of much geological interest; particularly as many differences of opinion existed among naturalists for a long time concerning the nature of that fossil: and the doubts of some, whether it be really the seed-vessel of a Chara, have not yet been set at rest. In order, however, not to interrupt with too much detail the course of the present paper, I shall treat of the Gyrogonites, and of the stems of Charæ which accompany them, in an Appendix. [See App. I.]

On the Origin of Shell-marl, and on the Circumstances which favour its Production.

Though frequently not a trace of organization can be discovered in the marl of Forfarshire, yet not a doubt can reasonably be entertained that it is derived from freshwater shells*, corresponding in the occasionally total obliteration of its original shelly texture with the white pulverulent marl of Glentilt, described by Dr. MacCulloch, and shown by him to result from land-testacea. (See Geol. Trans. vol. iii. p. 316.) In order, therefore, to explain the occurrence of the marl in the lakes of Forfarshire, it is only necessary to account for the accumulation of freshwater shells in those lakes.

In a paper on the Shell-marl of Scotland, (Geol. Trans. 1st series, vol. iv. p. 308.) Mr. Warburton has already remarked "that since shell-marl is not equally common in all the Scotch lakes, it may be worth inquiring what peculiar circumstances have favoured its production; whether calcareous salts are particularly abundant in the waters that yield it; and what are the rocks from which these waters spring, or which form the sides of the containing basins." I shall endeavour to throw some light on these leading topics of inquiry.

On viewing the principal deposits of marl in Forfarshire and in the eastern part of the adjoining county of Perth, it will be found that they do not occur in the districts consisting of granite, gneiss, mica-slate, clay-slate or greywacké, although those districts contain many lakes; but that marl-lakes are frequent in the inferior sandstone, and are not uncommon in the old red-sandstone, and that to these two formations they appear to be strictly confined†.

One of the remarkable features in the geology of the county of Forfar is

* The growth of Charæ may also have contributed to the secretion of calcareous matter; their stems containing, as will be found stated in the Appendix No. I., an abundance of carbonate of lime.

† See the accompanying Map. Plate XI.

the scarcity of limestone. That substance has been the object of careful search for agricultural uses; but the only situations in which it has hitherto been discovered are; 1st, in the districts of gneiss and mica-slate, where it forms some insulated masses: 2dly, in the inferior sandstone and shale, where it is, however, of much rarer occurrence: 3dly, in the old red-sandstone, where it appears forming a thin bed of cornstone*: lastly, as constituting the limestone of the Boddin near Montrose, which contains for the most part a small proportion of magnesia, and must either be considered as one of the lowest of the coal-measures, lying unconformably on the inferior sandstone series, or perhaps as belonging to the new red-sandstone formation. Lime, however, enters pretty extensively as an ingredient into the rocks of the two sandstone formations in which marl-lakes occur; both the old red and the inferior sandstone, as well as some of the trap-rocks which interrupt the regularity of the latter, containing a notable proportion of carbonate of lime. The rock seen on the surface *in situ* the nearest to the Bakie is the freestone of Lindertis, about a mile distant. It is a red-sandstone, slightly conglomeritic, containing a small proportion of carbonate of lime.

Concerning the water of the Bakie, I have already stated that no stream enters the lake; but it is fed by numerous springs, which burst up from the bottom in different parts, and are probably deep-sited, as they never fail in the longest droughts. I am indebted to Dr. Daubeny, Prof. Chem. Ox., for an examination of the water of the principal spring, which he finds remarkably pure and exempt from mineral contents, and in no way justifying the reputation it has acquired of possessing medicinal qualities. The specific gravity exceeds that of distilled water by less than $\frac{1}{300}$th part, and when evaporated in an exhausted receiver it bears only $\frac{1}{2000}$th of residuum. This residuum consists chiefly of dark-coloured vegetable matter; but it must also contain lime, since oxalate of ammonia renders the water turbid. The presence of carbonic acid is very evident.

It appears probable, therefore, that when the lake existed as such, the springs were the medium through which a continued supply of lime was secured for the perpetual growth and renewal of the testacea. The Charæ and other water-plants which are known to contain lime, are probably the instru-

* At Reedie, not 3 miles distant north from the Bakie, a bed of cornstone was once worked for lime, but it was soon exhausted. This bed does not pass under the Bakie, but dips from it, towards the Grampians, being to the south of the anticlinal line of the trough of Strathmore. In the eastern part of the county, the basset-edges of a similar bed may be traced for many miles, running north-east and south-west from Balmaqueen and Stracathro to Careston, where they nearly thin out. The cornstone of Reedie is on the continuation of the same line.

ments by which in the first instance that earth is secreted from the water; and from these plants, through the medium of food, it passes into the testacea. Accordingly, unless there are springs, a lake does not produce marl in any quantity, even though the lake be situated in one of the sandstone districts most favourable to its production. The growth of testacea, in such cases, is necessarily very limited, and their exuviæ cease to accumulate; because it is only from the decomposition of the exuviæ of a former race that the water-plants can obtain the lime which is requisite for their own support, and ultimately for the growth of a new race of testacea. In conformity with these views, we find that it is always near the springs that the marl is in the greatest quantity; because it is near to them that the testacea delight to congregate, partly owing to the greater clearness of the water, but principally to its uniform temperature, which occasions the water-plants to vegetate there in the very depth of winter. For the marl to be abundant, the springs must be copious; for it to be pure, the lake must be clear and free from muddy sediment; and must be fed therefore not by rivers, but by springs, as is the case with the Loch of Bakie.

On the Origin of the Tufaceous Limestone or Rock-marl.

The origin of the limestone or rock-marl appears to admit of only two reasonable explanations. 1st, It may be regarded as a tufaceous deposit from the springs in the bottom of the lake, which quitting their sources surcharged with carbonate of lime, on mixing with the water of the lake deposited that surcharge. As the tufas deposited in the open air from petrifying springs include terrestrial and aquatic plants and shells, so would tufa, formed, as upon our hypothesis, underwater, be found to envelope the native plants and testacea of the lake. But however natural this hypothesis may appear, the particular circumstances of the case do not warrant our adopting it; for the springs, instead of being surcharged with lime, contain only a small proportion of that earth; and consequently neither do they now, that the lake is drained, form a calcareous precipitate around their sources; nor can they have done so formerly at the bottom of the lake, before it was drained; unless (which is highly improbable) at some former period they contained lime in solution more copiously than at present. It is unnecessary therefore to dwell upon this hypothesis. We ought the more readily to discard it, because, although the springs in Forfarshire and the adjoining part of Perthshire contain an abundance of carbonic acid, they have not yet any where, except in connexion with shell-marl, been observed to deposit tufa.

2dly, The limestone or rock-marl may be considered as formed by the ac-

tion of the water of the springs on the previously existing shell-marl.—I have already stated that it is only near the springs that the rock-marl is found; that where it occurs, shell-marl has always hitherto been found beneath it, and that the water of the springs contains carbonic acid. May we not then reasonably suppose that this carbonated water, in percolating the lowest deposits of shell-marl, took up from them a portion of lime; and on mixing with the water of the lake at a further distance from the source, let fall a calcareous precipitate, which in some places falling alone, produced a pure crystalline limestone, and in others, mixing with the later deposits of shell-marl and the various lacustrine plants, had the effect of cementing them together into one tufaceous mass.

The only other instance that has come to my knowledge in this part of Scotland of a limestone similar in character and in the circumstances of its occurrence to that of the Bakie, is in the moss of Cookstone, near the Bakie, and like that loch, occupying one of the hollows between hillocks of diluvium. For this piece of information I am indebted to Mr. Blackadder of Glammis, a gentleman well skilled in every branch of geological research. An inconsiderable quantity was discovered in cutting peat; but nothing further can at present be ascertained respecting it. If a similar rock has been found in any other marl-loch, it is probably in very small quantity; for marl is so extensively worked in this part of Scotland, that were there any considerable mass of the substance in question, it could scarcely have escaped observation. A formation, however, is now daily going on in the Loch of Forfar, which, though not strictly analogous to that of the Bakie and of Cookstone, may still tend to throw some light on the subject. For the first intimation of the existence of this formation I am also indebted to Mr. Blackadder.

Tufa in the Loch of Forfar.—The Loch of Forfar was never more than partially drained; and the marl can only be procured there by dredging it from the bottom. When the level of the lake was first lowered, a bed of shell-marl of very pure quality was left dry on its southern bank, some of which, being too thin to be worth working, still remains there. It has been since buried by the falling in of some of the diluvial gravel of the bank above, part of which has also covered the bottom of the lake near the shore. The water, when the lake is very full, or the wind high, washes the edge of the bed of marl in the bank, and becomes milky from the quantity of calcareous matter suspended in it. From this fluid a deposit is constantly taking place, and a thin crust of calcareous tufa, which scarcely ever attains the thickness of an inch and a half, falling on the gravel, cements it together, and forms a breccia. It occasionally incloses a few shells, chiefly of the *Helix peregra*. These have

been washed out of the soft marl, which itself contains but few of them. This formation extends for about 100 yards along the southern border of the lake, and is confined to that part which in summer is dry, and in winter lies below the level of the water.

Comparison of the Limestone of the Bakie with other Freshwater Limestones both of recent and of ancient Formation.

The limestone of the Bakie very closely resembles the tufa deposited from springs, which issuing highly charged with carbonic acid or sulphuretted hydrogen from limestone strata, contain a quantity of lime in solution. Such deposits are common in most calcareous districts; but are particularly abundant in some parts of Italy; as, for instance, at the waterfall of Terni, and at the baths of St. Philip on the frontiers of Tuscany some miles from Radicofani, and near Rome at the cascade of Tivoli and the lakes of Tartari and Solfatarra. The tufa of the last-mentioned lake is compact, and in that respect comes nearest to the ancient freshwater limestone of the same country. [Oss. Foss. 2d edit. tom. ii. pp. 550, 552.]

The *modern* deposit however, the most analogous to that of the Bakie, is that described by M. Beudant, as daily forming underwater at Czegled and other places in the great plain of Hungary. The limestone thus produced is of a grayish or yellowish colour, divides naturally into slabs, and is sometimes sufficiently solid to serve for building. It incloses Planorbes and other shells identical with those now living in the neighbouring marshes. It is traversed by irregular tubes which are perpendicular to the surfaces of the slabs; and are considered by M. Beudant as having been caused by the disengagement of gas. [Voyage en Hongrie, tom. ii. p. 353, and tom. iii. p. 285.]

Of the *ancient* freshwater limestones, the most similar to the rock-marl of the Bakie are those of Italy. This kind of limestone, having been quarried extensively by the Romans near Tivoli, (Tibur,) has acquired in Italy the name of Travertino (*lapis Tiburtinus*), a term now applied also to modern tufa and to any very soft and cavernous limestone. The travertino is white when first taken from the quarry; but after a time it becomes yellowish, and at length acquires that reddish hue which is so agreeable to the eye, and so much heightens the architectural effect of the monuments of ancient Rome. [Breislak. Inst. Geol. tom. ii. p. 123.] It is the material, in fact, of which not only the Coliseum and many other ancient works in Rome are constructed, but also the far older temples in the Grecian colony of Pæstum.

The travertino of the great quarries of Ponte Lucano, at the foot of the hills of Tivoli, is described by Von Buch as lying in horizontal beds, and as

being principally characterized by the cavities which traverse its substance. "These cavities," he observes, "are of two kinds: the former, small, lengthened, dull in the interior, and often inclosing vegetable remains, by which they seem to have been occasioned; the latter, very long, passing from the top to the bottom, and so parallel to one another as to appear artificial." [Geog. Beobach. band. 2. seite 26.] These cavities are considered by M. Brongniart as of invariable occurrence in the freshwater limestones of all countries, and as absolutely characteristic of such formations. [Oss. Foss. 2d edit. tom. ii. p. 548.] Similar cavities were noticed by M. Omalius d'Halloy in the travertino near Cisterne, at the entrance of the Pontine Marshes, on the road from Rome to Naples; and he also observed the occurrence of Lymneæ and Helices in the rock. [Journ. des Mines, tom. xxxii. p. 402.] The freshwater formation of the valley of the Elza, in Tuscany, towards Colle, is described by M. Brongniart as presenting, 1st, upon the heights, as you descend towards the valley, a very compact limestone of great extent and thickness: 2d, at a lower level, a fine sand, inclosing Neritæ which retain their colour, and a multitude of other freshwater shells: 3d, on descending the valley, a stratum, which consists either of compact limestone traversed by sinuous cavities, and containing freshwater shells and flinty portions that gradually pass into the matrix; or of a porous rock resembling tufa, composed apparently of the stems of Chara and Myriophyllum converted into limestone. [Oss. Foss. 2d edit. tom. ii. p. 554.]

There is scarcely more than one circumstance in this description (and to that one I shall recur in the sequel) to which a parallel cannot be found in the deposits of the Bakie. Nor ought the resemblance which the ancient travertino bears, in common with modern tufa, to the rock-marl of the Bakie, to be thought surprising, when we consider what the origin of the former has been, in the opinion of the most able geologists. It is regarded by them as a deposit which has been formed, at periods more or less remote*, in the natural hollows of lakes; the extent of those lakes being in some cases yet assignable; and the supply of the calcareous matter which formed the deposit, has been traced by them to springs or streams which existing in the very districts in

* MM. Brongniart and Omalius d'Halloy, who have each examined the travertino of the Campagna, differ considerably in their estimates of its antiquity. The one, not finding on its surface any marks of diluvian action, considers it as of post-diluvian formation [Journ. des Mines, tom. xxxii. p. 405.]: the other, referring, it should seem, to one epoch the travertinos of the Campagna and of Tuscany, must regard that epoch as ante-diluvian; since the surface of the Tuscan travertino has been greatly modified by diluvial excavation. [Oss. Foss. 2d edit. tom. ii. pp. 551, 554.]

question, still precipitate tufa. Thus M. Omalius d'Halloy considers the plain of Ponte Lucano, between Rome and Tivoli, as the site of a lake which has become filled up with beds of travertino; and the small lakes of Tartari and Solfatarra, which still deposit tufa, as the remains of this ancient expanse of waters. [Journ. des Mines, tom. xxxii. p. 405.] In the same manner, nearly, M. Brongniart traces the origin of the hills of travertino which bound the valley of the Elza in Tuscany, to rivulets actually existing which still deposit tufa, and which, before the surface was modified by the diluvian excavation of that valley, flowed out and deposited tufa on a level with the summits of those hills. [Oss. Foss. 2d edit. tom. ii. p. 554.]

In their Essay on the Geology of the Environs of Paris (p. 56), MM. Cuvier and Brongniart state, that they regard the freshwater strata of that country as deposits formed in an immense freshwater lake; and they infer from the character of those deposits, that the freshwater of the ancient world possessed properties which are not observed in that of our modern lakes: in the latter we find deposits of friable mud only; but in the lakes of ancient date there were formed thick, and often very homogeneous, deposits of yellowish compact limestone, of whitish marl, and of flint, which have enveloped the remains of the living inhabitants of the lakes, and have converted the original substance of those remains into that of the calcareous or siliceous matrix which surrounds them.

Of the four particulars here enumerated as establishing a distinction between the deposits of ancient and modern lakes, no less than three are supplied by the marl-loch of the Bakie; since, 1st, we have a very compact limestone, crystalline in parts; 2d, extensive deposits of white and yellowish calcareous marl, in which testaceous remains are only of casual occurrence; 3d, vegetable remains wholly converted into limestone. The only characteristic peculiarity to be noticed in recent lacustrine deposits, not excepting those of the Bakie, wherein they fail to preserve their analogy to the ancient ones, is the non-occurrence in the former of flint, either nodular, like that imbedded in the travertino of the Elza, or stratiform, like that presented in the siliceous and calcareo-siliceous beds of the basin of Paris. Except in thermal waters, decidedly under the influence and in the proximity of volcanos, no aqueous deposits of silex have been seen in the act of forming: M. Brongniart therefore conjectures, with some appearance of probability, that the silex of ancient freshwater formations was precipitated where we now find it, from the water of thermal springs.

On the many other analogies which the deposits of the Bakie, in common with most other recent lacustrine deposits, bear to those of ancient lakes, it is

not my intention to dwell. It is well known that ancient freshwater deposits in many cases consist almost wholly of loose materials, such as marl, clay, and sand, either disposed in alternating layers, or variously blended with one another; and such also are the principal contents of the Bakie, and the entire contents of most of the marl-lochs in Forfarshire. Between the aquatic plants and animals of the two epochs the closest relation subsists, the genera in the two cases being nearly identical. Thus we find in both formations: among the Testacea,—Lymneæ, Planorbes, &c.; among the Crustacea,—the genus Cypris; and among the plants,—the genus Chara, with its fossilized seed-vessel the Gyrogonite. Even between the terrestrial animals of the two epochs the relation does not wholly fail; since in both instances, imbedded in the deposits, occur the remains of large Mammalia. Nor is the magnitude of the ancient freshwater lakes without a parallel among recent formations, although the modern process of deposition may in most instances, either from a reduced scale of temperature or from the smaller dimensions of the present race of testacea, be comparatively slow. Thus the surface of Lake Superior alone is half as large again as the area of the three tertiary basins of Paris, London and Hampshire united, of which basins only very limited portions are occupied by freshwater deposits; and the same lake is considerably greater than the great tertiary basin of the south of France. That these American lakes are forming deposits, and the nature of the deposits so formed, we fortunately are enabled to ascertain, in consequence of the subsidence of the waters of Lakes Superior and Huron, occasioned by the partial destruction of their barriers. These deposits may be traced along their present shores: on Lake Superior they consist of clay, sand and gravel; and on Lake Huron, below beds of sand 150 feet thick, we have similar beds of clay, inclosing shells of the very species which inhabit the lake, and which are of great size and thickness. [Dr. Bigsby in the Journ. of Science, &c. No. 37. pp. 262, 263.]

On several other Recent Deposits of Freshwater Marl.

Having now terminated my description of the freshwater deposits of the Bakie, I shall give a brief account of some other deposits of marl with which I am acquainted.

1. *Marl of the Loch of Kinnordy.*

The Loch of Kinnordy lies in the same geological district with the Bakie, about 6 miles to the north-west of it*. It is closed up at its bar by a mass *in*

* The loch, or rather the marl-meadows, of Logie are situate nearly in the same direction, and at the same distance from the Bakie.

situ of those red argillaceous beds, belonging to the old red-sandstone, termed *calm.*

The marl, before it was worked out, was thickest at the west end of the lake, where the springs are most numerous. It is usually divided into two beds by an intervening layer of clay, from 1 to 2 feet thick. The upper bed abounds in shells, of the very same species that occur in the Bakie; and these shells, like those of the Bakie, are the growth of young testacea, scarcely one in ten being full-sized. In the lower bed the shells have disappeared; or if any exist, they are very rare. In this bed the seed-vessels of Charæ are abundant. In those specimens which I have found, belonging to *Chara hispida,* the outer integument is not fossilized, as it is in those enveloped by the rock-marl of the Bakie; though still it is more calcareous than in the living plant. The nut is always found within, black and much shrunk from decay. The marl from both the beds is argillaceous, and contains a less per-centage of lime than most of that from the Bakie. Scales of mica are frequent in it, and it is usually divisible into thin laminæ, between which the flattened stems of vegetables occur in great abundance.

The clay which separates the two beds of marl is generally reddish, and has been derived, apparently, from the *calm.* Like the marl, it divides into thin leaves. From this texture, I am disposed to believe that it was deposited gradually, and not that it resulted from a single influx of mud. While the clayey matter remained suspended in the water, the testacea must have been unable to live; and this may not improbably be the cause why the clay contains neither shells nor calcareous matter.

In the upper bed of marl, during the last autumn, the skeleton of a stag (*Cervus elaphus*) of large dimensions was dug out. The horns had 9 branches, and weighed, when dry, nearly 18 pounds. The skeleton was in a vertical position; the tips of the horns reaching nearly to the surface of the marl, and the feet nearly two yards below. The marl was immediately covered by peat, in which also the skeletons of stags are occasionally discovered. Since the bones of quadrupeds are frequently met with in the marl by the workmen, much knowledge may be obtained of the former post-diluvian wild inhabitants of this country, by paying to the subject that attention which it deserves*.

* In the summer of 1820 a canoe was found in the peat, one extremity being scarcely below the surface [see Pl. X. fig. 2.]. It was formed out of a single block of oak; its length from head to stern was 15 feet, its width within 3 feet. There were no marks of thowels or row-locks on the sides for rowing; so that it appears to have been paddled like a canoe, which it resembled in form. There is a seat for the boatman near the stern. The prow had evidently been carved into an ornamental shape, representing, apparently, the head of some animal. The stern was

II. *Marl near Romsey in Hampshire.*

The meadows near Greatbridge, about a mile north of Romsey in Hampshire, afford the only locality in England where I have as yet seen shell-marl. It has been applied there to agriculture for many years with advantage. It occupies an alluvial tract in the valley of denudation through which the river Test flows, traversing the plastic clay formation, near the northern confines of the tertiary basin of Hampshire and the Isle of Wight. The following is a section of one of the above-mentioned deposits in Ashley Meads, beginning at the top.

	Thickness.
1. Alluvial clay unmixed with marl	from 1 to 2 feet
2. Shell-marl provincially termed "*malm*"	2 — 6
3. Peat of various thickness, sometimes	6
4. Clay and gravel (diluvium?)	

The chief substance of the marl consists frequently of shells; sometimes, however, about one half of it is a calcareous matter, which often forms concretionary balls of some solidity; these however fall to pieces immediately upon exposure to the air and frost. These concretions bear no resemblance to the rock-marl of the Bakie. They are never compact, but of a loose texture and brownish yellow colour; they contain some iron. These and all the accompanying marls when heated afford a considerable quantity of ammonia, with a smell of burnt animal matter. I am obliged to J. E. Gray, Esq., F.G.S., of the British Museum, for the names of the following shells found in this marl.

Names of Montagu.	*Names of Lamarck.*
1. Helix putris	Succinea putris.
2. —— arbustorum	Helix arbustorum.
3. —— hortensis	—— hortensis.
4. —— nemoralis	—— nemoralis.
5. —— carinata	Planorbis carinatus.
6. —— complanata	——— complanatus.
7. —— contorta	——— contortus.
8. —— alba	——— albus.
9. Bulla fontinalis	Physa fontinalis.
10. Helix peregra	Lymnea peregra.
11. —— fragilis	——— stagnalis (var.)
12. —— auricularia	——— auricularia.
13. —— palustris	——— palustris.
14. —— ovata	——— ovata.

---

the only part that had suffered injury. This relict is not without its value to the Geologist, as well as to the Antiquarian; since it shows that some part even of the peat, which overlies all the marl, is of a date anterior to the historical records of the country.

Names of Montagu.	*Names of Lamarck.*
15. Turbo fontinalis	Valvata piscinalis.
16. ——— cristatus	——— cristata.
17. Helix tentaculata	Paludina impura.
18. Patella fluviatilis	Ancylus fluviatilis.
19. ——— lacustris	——— lacustris.
20. Tellina cornea	Cyclas cornea.
21. Cardium amnicum	——— obliqua.

In the marl occur branches and trunks of trees but little altered, and frequently encircled with whitish calcareous concretions, several inches thick, consisting of the same substance as the nodules before mentioned. Both in the marl and peat have been found the bones of many animals. Mr. Daman of Romsey has formed a collection of some of these remains, among which Professor Buckland recognised the bones of the stag, roebuck, beaver, pig, and ox. Springs are common in these alluvial tracts. The marl occupies irregular spaces, surrounded, and often abruptly terminated, by peat. The spots in which it is found are usually elevated some feet above the level of the alluvial flat of the Test, and are called by the workmen, from that circumstance, "*malm-knolls.*" There are places where the marl is overlaid by peat, and where the two are intermixed, forming what the workmen call *black malm* and *white peat.*

Of these facts the following explanation may be offered.—The low grounds by the side of the Test were first covered by peat, which the river occasionally overflowed, carrying with it drift timber and the bones of such animals as by different casualties had perished in the water or within reach of floods. In different parts of these marshes, however, there remained pools of still water, in which freshwater testacea subsisted. The numerous land-shells which are found mixed with the aquatic species, belonged to testacea inhabiting the borders of the river, which, when high, still passed into these lakes, and drifted in occasionally, together with the shells, the wood and peat now sometimes found intermixed with the marl. At length the basin was filled up with shell-marl; testacea could no longer exist there; and in some places a small increase of peat took place on the surface of the marl. Lastly, the river covered in some parts (as at Ashley Meads) both the marl and the peat with alluvial clay, without any admixture of shells or of marly matter. This last operation was in all probability the result of several floods, during which the waters rested some time on these flats; so that the argillaceous sediment sometimes attained the thickness before mentioned. To account for the present elevation of the marl above the banks of the pools in which it was formed, Mr. Daman suggests, that the peat when no longer on the increase, after be-

ing covered by clay, would shrink considerably; while the marl would not contract,—or if at all, not in the same proportion. The author of this memoir has himself had occasion to witness, in the moss of Kinnordy in Forfarshire, the remarkable degree in which peat shrinks, when the quantity of its water is diminished. In that Moss, the peat, since its drainage, has in many parts lost by subsidence half its original thickness.

The Test flows more rapidly than most of the rivers in the South of England. Its water is very clear, and remains so during the highest floods. From its sources to the north of Whitchurch and Andover, until it arrives near Brook, about four miles and a half above Ashley Meads, where the marl occurs, it flows through a district of chalk. After leaving the chalk, it enters the plastic clay formation. In the muddy deposits formed in the slow-running parts of the river, the exuviæ of testacea are very abundant. The river is not known to deposit calcareous matter any where at present, either in its channel, in the ditches and drains, or in the meadows, during floods. Calcareous marly matter has never yet been found in this neighbourhood unaccompanied by shells.

Appendix I.

On the Chara, and on its Seed-vessel, the Gyrogonite.

For all that is valuable in the botanical remarks that occur in the present Appendix on recent and fossil Charæ, I am indebted to the assistance of Mr. Brown and Mr. James De Carle Sowerby.

M. Leman, in a notice published in the Nouv. Bulletin des Sciences, tom. iii. No. 58. p. 108. for 1812, first identified the Gyrogonite with the seed-vessel of some unknown species of Chara. He has remarked also, in the same memoir, "that the gyrogonites are sometimes accompanied by small irregular tubes whose coats (*parois*) are also tubular, and whose central cavity is transversely striated; that the structure is identically the same with that of the stems or branches of Charæ, particularly of *C. vulgaris* and of *C. tomentosa**." M. Brongniart has figured one of these fossil stems; but the transverse striæ in the central cavity (or rather septa, as they are there represented) which are

* Ann. du Mus. d'Hist. Nat. tom. xv. Pl. XXIII. fig. B. copied in Journ. des Mines, tom. xxxii. Pl. VIII.

alluded to by M. Leman, do not appear in *C. vulgaris*, nor in any of the Charæ mentioned in this memoir. In some of these, as in *C. vulgaris*, septa occur at the points where the leaves or small branches are set on; or even independently of these points, in *C. flexilis** (see Pl. XII. fig. 4—6); but in these cases they are distant from each other.

Seed-vessels of Charæ.—The pericarpia or seed-vessels of Charæ consist of a membranous nut covered by an integument. (See Pl. XII. fig. 1. *f.*) The nut is spirally striated or ribbed. In some specimens of *C. hispida*, from the Bakie, the nut inclosed within a fossilized integument, admitted of the spiral parts being separated, precisely like the valves of a ripe integument. (See Pl. XII. fig. 1. *f.*) It is of consequence to observe that in this part of their structure, the nut and the integument do not appear to differ; for the nut of the ancient fossil gyrogonites being sometimes found without the integument, were we not aware of this structure, might be supposed to belong to a distinct species.

The integument is composed of 5 spiral valves. These valves are of a quadrangular form (see section of one, Pl. XII. fig. 1. *i.*): they are attached by their inner edges to the striæ on the nut, which is well exemplified in section of *C. Medicaginula* from the Isle of Wight. (See Pl. XIII. fig. 2. *b.*) The valves of the living plant appear, under the miscroscope, to contain within a thin membrane a transparent brittle substance, perhaps carbonate of lime. An outline drawing of a species of Helicteres from the West Indies, with which Mr. Brown has favoured me, has been introduced, as its shape offers a striking subject of comparison with the integument and nut of the pericarpium of the Chara. (See Pl. XII. fig. 5.) The analogous form is in both instances produced by the twisting together of 5 spiral tubes; although the analogy does not hold when the parts of the plants are compared, of which these tubes are constituted: for in the Helicteres they consist of 5 spiral capsules, but in the Chara, of 5 spiral valves, forming together the integument of a single capsule. It should also be observed that the capsules in the Helicteres wind round in a contrary direction to the valves of the Chara.

Stems of Charæ.—The stems of Charæ may in general be described as composed of a large tube, surrounded by smaller tubes. (See Pl. XII. fig. 1. *m.* fig. 2. *g, h.* fig. 3. *g.* Pl. XIII. fig. 6.) In some, however, there is only one single tube. The smaller tubes are irregular in number. In specimens of *C. hispida*, for instance, the numbers 10, 11, 12, and 13, were observed.

Gyrogonite of the Bakie.—It may be convenient to retain the term Gyrogo-

* See Note, p. 93.

nite, which was first used, when the true nature of these bodies was unknown, to express the fossil or mineralized state of the pericarpium of Chara. The gyrogonite, which occurs in the rock-marl of the Bakie, consists in general of the empty integument completely replaced by carbonate of lime. (See Pl. XII. fig. 1. *a, b, c, d, g, h.*) Sometimes, however, the nut is found within, as a flexible, brown membrane, not fossilized. (See Pl. XII. fig. 1. *e, f.*) In the ancient gyrogonites, as was before observed, the nut, as well as the integument, is sometimes replaced by the substance of the matrix*. (See Pl. XIII. fig. 2. *b.*) In the Bakie gyrogonite, as in the ancient ones, the spiral valves are easily separable. (See Pl. XII. fig. 1. *g.*) This gyrogonite, as well as the accompanying stems, was found upon a careful comparison to agree with *C. hispida*. The fossil represented in Pl. XII. fig. 1. *a.*, will appear larger than its recent analogue, Pl. XII. fig. 2. *a.*: but this arises from the difficulty of procuring a ripe specimen of the recent seed-vessel; as in that state they fall off readily from the plant. The stems fossilized in the rock-marl are sometimes empty (see Pl. XII. fig. 1. *m.*), but more frequently they are filled with carbonate of lime.

C. hispida.—Chara hispida abounds at present in the Bakie Loch, and in other lakes in Forfarshire. It contains so much carbonate of lime in its vegetable organization, and independently of calcareous incrustation, as to effervesce strongly with acids when dried. Each of the 5 spiral valves of the seed-vessel turns rather more than twice round the circumference, the whole together making between 10 and 11 rings. The number of these is very constant. (See Pl. XII. fig. 2. *a, b.*) The stems of *C. hispida* are longitudinally striated, with a tendency to be spiral. These striæ (as appears to be the case with all Charæ) wind round in a contrary direction to the spiral valves of the pericarpium (see Pl. XII. fig. 2. *f, g.*): *i. e.* the striæ of the stems turn always like the worm of a screw, from right to left, (as is the case with the Convolvulus and the Helicteres (see Pl. XII. fig. 5.); the valves of the capsule turn from left to right (as is the case with the honey-suckle), a fact which, from the figures of Charæ given by botanists, appears not to have been attended to.

* I find that some specimens of gyrogonite (*C. helicteres*, Brongn.) which I collected in 1823, when on a tour with M. C. Prevost, from a thin stratum of greenish argillaceous sand, of the upper freshwater formation in the Forest of Fontainbleau, allow the outer convex coat of the valves to peel off, and leave what resembles the replacement of the nut within, very much as in *C. Medicaginula* of the Isle of Wight (Pl. XII. fig. 2.), but not so firmly united. The integument in these is very fragile, and the nut tender. Were the capsules imbedded in a more compact matrix, the nuts would probably be easily extracted. The stratum in which the above gyrogonites abounded, was exposed in a quarry at "Les Rochers du Fort des Moulins," near Les Basses Loges: beneath it was the Gres de Fontainbleau *in situ*.

The short bristly prickles which distinguish the stems of *C. hispida* are so easily detached, that they can scarcely be preserved even in dried specimens, and are always wanting in the fossil.

C. vulgaris.—This plant inhabits the Bakie and other lakes in Forfarshire. Although I have not yet met with its seed-vessel fossilized in the rock-marl, yet I cannot doubt that it exists there: for in that rock a large quantity of fossil stems are found, agreeing exactly in size and appearance with those of *C. vulgaris*, which are not above half the diameter of those of *C. hispida*. They are scarcely otherwise distinguishable, except that the striæ are less deeply indented.

The seed-vessel is smaller and more obtuse than that of *C. hispida* (see Pl. XII. fig. 3. *a, b.*); but the spiral valves form the same number of rings. Dr. Brewster states that carbonate of lime occurs crystallized according to a regular arrangement beneath the cuticle of the stem of this species. [Edin. Phil. Journ. Jan. 1823. No. 17. p. 194.]

C. flexilis *?—A figure of this species is added, as it inhabits most of the marl lakes in Forfarshire, though not found in the Bakie. The spiral valves of the seed-vessel turn each about $2\frac{1}{2}$ times round the circumference, the whole together forming about 13 rings, which exceed the number in *C. hispida* and *vulgaris*. (See Pl. XII. fig. 4. *a, b.*)

C. Medicaginula (*fossil*).—The external integument of this species is figured by M. Brongniart. [Oss. Foss. 2d edit. vol. ii. Pl. XI. fig. 7.] The present section is taken from one occurring in the lower freshwater formation at Gurnet Bay in the Isle of Wight. It exhibits the fossilized nut as inclosed in the integument, more distinctly than in any specimens which I have seen from the Paris Basin. (See Pl. XIII. fig. 2. *b.*) The integument frequently adheres to the stone, while the nut is easily detached. (See Pl. XIII. fig. 3, 4, 5.)

It will be remarked that in these three specimens the number of the ribs or striæ on the nut varies from 5 to 7; yet it is possible that they are referrible to the same species; a point which cannot be decided until more botanical knowledge has been acquired on the fructification of this tribe of plants. Fig. 5. Pl. XIII. represents one from the same group which is more elongated, but of which the shape has perhaps been distorted. As the number of ribs are nine, and the intermediate striæ are wanting, it may belong to a distinct species.

A drawing of a fossil stem accompanying the above-mentioned gyrogonites

* *Chara flexilis*, here alluded to, has been recognised by Dr. Hooker as the *C. flexilis* of his Flora Scotica; but he has observed in that work, that botanists have experienced considerable difficulty in distinguishing the Charæ.

shews the exact correspondence between its internal structure and that of the stems of many recent Charæ. (Pl. XIII. fig. 6.)

C. tuberculata (*fossil*).—This beautiful species of gyrogonite (Pl. XIII. fig. 7, 8.) differs from any yet described in having the valves ornamented by a row of obtuse tubercles, very regularly disposed. I found it very abundant in a compact siliceous limestone, belonging to the lower freshwater formation between Bembridge and Culver Cliff in the Isle of Wight*. The outer integument alone occurs, the nut being always wanting. Its shape is almost spherical; the spiral valves form constantly nine rings.

* This new species of gyrogonite was found in White-cliff Bay, close to the point of junction between the horizontal strata of the upper marine and lower freshwater formations, and the vertical beds of the London and Plastic clays. This junction is represented by Mr. Webster in Plates XV. and XVII. of Sir H. Englefield's Isle of Wight.

As I believe no account has yet been published of the strata at this point, the following brief notes, which were made when I collected the specimens, may not be unacceptable.

Strata, beginning from the top.

1. Diluvium, sand, gravel, &c.
2. Clay of the upper marine formation with numerous oysters.
3. White calcareous marl, compact, with earthy fracture, having a slightly argillaceous smell. In this I observed no organic remains.
4. Gray calcareous marl, compact, with earthy fracture, filled with the casts of numerous univalves, which have in general left the hollows which they occupied, empty. They are of the genera Planorbis, Lymnea, Helix, and Paludina. Gyrogonites also occur chiefly of *C. tuberculata*; but I have found one of *C. Medicaginula*.
5. White calcareous marl, like No. 3.
6. A very compact gray limestone, with conchoidal fracture, containing numerous casts of Lymnea and Planorbis. The gyrogonites in it are very numerous, all belonging to *C. tuberculata*. They are replaced by crystals of carbonate of lime. The nut is never within, the integument alone remaining.
7. Calcareous marl, somewhat resembling No. 3, but grayer, inclosing a few casts of Planorbis, small black shining fragments, and a few minute pieces of bone.
8. White calcareous marl, resembling Nos. 3 and 5.
9. Compact limestone, fracture conchoidal, contains gyrogonites (*C. tuberculata*) in the same crystallized state as in No. 6.
10. White calcareous marl, like Nos. 3, 5, and 8.
11. Friable calcareo-argillaceous marl, containing a few Planorbes of which the shells remain. It is mottled with oxide of iron. This bed is washed by the sea and covered at high water.

Each of the above freshwater strata, from No. 3 to 11 inclusive, are very nearly of the same thickness, varying from 3 to 4 feet each. They have a slight northerly dip.

Appendix II.

I am indebted to Mr. Faraday, F.R. and G. S.S., of the Royal Institution, for an examination of different specimens of marl, limestone, &c., which originated in a desire to ascertain whether the marl afforded any traces of animal matter. It appears from this examination, that the test applied is so exceedingly sensible to the smallest traces of ammonia; and that these traces may be communicated to the specimen under trial by causes so slight, that the indications given by the test of the presence of ammonia afford but equivocal proof that animal matter existed originally in the specimen. This being the case, although all the marls from the Bakie, &c. gave, when tried, unequivocal signs of the presence of ammonia, I have omitted any mention of that circumstance in the text.

The following, as Mr. Faraday informs me, was the test employed. "The marl was heated in a glass tube to a red heat, upon which it gave out the smell peculiar to burnt animal matter. Turmeric paper, upon being brought near it, was tinged of a reddish brown colour, indicating the presence of ammonia; the tint disappearing upon the application of a moderate temperature.

"The delicacy of this test is such, that it is necessary, not only that the glass tube should be previously examined, but that the specimen should be fresh from the centre of a mass and not handled. The importance of such attention will be shown by the following experiment.

"Some sea-sand was heated in a crucible to red heat for half an hour, and then poured out on a copper plate and left to cool. A portion of it was then introduced into a glass tube by a platina spoon, and it caused no change of colour in the turmeric paper; but another portion of the sand which had been heated, upon being poured into the palm of the hand, turned over several times by the finger and then examined in the same manner, gave decided traces of ammonia. It may be interesting to enumerate the different substances, which when examined with due attention to the circumstances above stated, gave indications of ammonia. The result will serve as a caution against founding any theory on the presence of that alkali, except when it is very abundant."

1. Loose calcareous marl, from the Upper Freshwater formation, Isle of Wight . . . . *slight indications.*
2. Limestone of the Lower Freshwater formation, White-cliff Bay, Isle of Wight . . *slight.*
3. Gypsum, from *Gypse à ossemens.* Trielle, in the Paris Basin . . *plentiful, with smell of fetid limestone.*
4. Bone of quadruped, from ditto . . *afforded no indications of ammonia, but the smell of burnt animal matter.*

5. Shell from Calcaire Grossier, Grignon . . . . . *plentiful.*
6. Chalk, from stratum without flints, from Culver Cliff, Isle of Wight . . . . . *slight.*
7. Portland rock with shells . . . . . *plentiful.*
8. Transition limestone from Dudley, with trilobite . . . . . *slight.*
9. Gray slate from transition series, Forfarshire . . . . . *slight.*
10. Limestone imbedded in gneiss, from Glen Isla, Forfarshire . . . . . *slight.*
11. Ditto, Glen Isla, Forfarshire . . . . . *slight.*

The two last specimens of primitive limestone yielded no signs of ammonia until pulverized. As its occurrence in these is remarkable, it is possible that water percolating the rock may have conveyed down a slight quantity of ammonia, since the specimen examined was not far distant from the surface.

12. Carrara marble . . . . . *afforded no signs of ammonia.*

IX.—*Geological Sketch of the North-western Extremity of Sussex, and the adjoining Parts of Hants and Surrey.*

By Roderick Impey MURCHISON, Esq. Sec. G.S., F.R.S., &c. &c.

[Read December 16th, 1825.]

I PROPOSE to illustrate in this memoir the order of superposition of the strata in that north-western part of Sussex which is bounded on the south by the chalk escarpment of the South-downs, and in those adjoining parts of Hampshire and Surrey which are bounded severally, on the west by the Alton chalk-hills, and on the north by the North-downs.

Having examined a portion of this country with my friend Dr. Fitton, I was encouraged by him to attempt an exact delineation of the whole, by colouring the Ordnance map according to geological formations *. This task being now accomplished, I beg to lay the result before the Geological Society, together with such illustrative specimens of the strata and their fossils as I have been able to collect in the course of last summer.

The formations of which this district is composed, begin to emerge from the superior strata at the northern extremity of the parish of Bentley in Hants, 6 miles north-east of Alton; and they range from thence to the south and east, until their escarpments are cut through by the Arun, which river I have chosen to make the limit of my present observations.

The chalk escarpments of the Alton hills and of the South-downs, converging towards Petersfield, are united at an acute angle in the parish of East Meon, 4 miles west of the former place; and within that angle the inferior strata are disposed conformably. Hence by assuming the Weald clay in the little valley of Harting Combe as the *nucleus* of the district, a regular succession is developed up to either chalk-range, and the breadth of each intermediate formation which mantles round the Weald clay, is shown by the map and section annexed.

The same order of superposition having been clearly established in the

* Pl. XIV. is a sketch taken from the coloured copy of the Ordnance map alluded to in the text.

sections of the coast of the Isle of Wight*, my object is to point out the identity of this extensive inland tract, in which all the members of the series, from the chalk to the beds below the Weald clay, appear to be more largely and uninterruptedly displayed than in any other part of England. It is the more necessary to define accurately all the strata of this district, inasmuch as three of the formations have been hitherto described to be one range of green-sand; whereas the upper green-sand is divided from the lower, throughout the whole of this country, by a distinct and important breadth of *Gault clay*, of which the royal forest of Alice Holt forms the north-eastern portion.

The strata, therefore, the relations of which it is my object briefly to describe, commencing below the chalk in a descending series; are,

1st. Firestone, or Upper Green-sand.
2nd. Gault.
3rd. Lower Green-sand.
4th. Weald Clay.
5th. Hastings or Iron Sand.

I. *Firestone, or Upper Green-sand.*

This formation, which lies immediately below the chalk, is provincially termed Malm-rock, and is known by that name alone in the counties of Hants and Sussex, throughout a range of 40 miles. Its geognostic position and the fossils it contains, prove it to be geologically identical with the upper green-sand or firestone of Merstham. The beds are nearly horizontal, or they dip at only a slight angle towards the chalk. The whole formation is peculiarly characterized by constituting *terraces*, which vary in breadth from a quarter of a mile to two and three miles, and which generally correspond to the sinuosities of the chalk hills. These terraces are covered by a tenacious grayish-white soil, celebrated for its abundant production of wheat. Quarries are to be seen in all the lanes which intersect this country; and in many places the sides of the roads, which by the rapid decomposition of the rock are worn into deep hollows, present sections from 20 to 30 feet deep. The harder beds are used for building; and though the occurrence of firestone is not frequent, still that variety is seen in some places, at Selborne for instance, where it is employed in the construction of ovens.

The upper beds are the most cretaceous; but these sometimes pass into a grayish-blue compact limestone, which is of great thickness at Binsted and

* See Annals of Philosophy, 1824, New Series, vol. viii.

Froyle in Hants, and at Sutton in Sussex:—occasionally a blue chert may be observed.

The inferior beds have a softer and more sandy character, particularly near their junction with the Gault.—The depth of the wells sunk in this stratum varies from 60 to 100 feet.

The fossil shells, though belonging to few species, are extremely numerous: they are usually much compressed; and the beds in which they abound being of a perishable quality, they are very fragile.

Those which I have collected are chiefly from Nursted and Buriton, Hants.—The following names were obligingly afforded me by Mr. Sowerby, who examined the specimens.

Ammonites rostratus.
Ammonites varians.
Pecten orbicularis.
Gryphæa vesiculosa.
Avicula. New species not yet figured.
Echino-spatagus. New species figured and named in the Icon. Sect. Foss. cent. 2da of König.
Fish:—fin of the Balistes?

Circular impressions and highly indurated cylindrical bodies, probably portions of stems of Alcyonia, are very frequent.—Of the above fossils, the *Ammonites rostratus* and the *Pecten orbicularis* are the most abundant and characteristic, the latter especially being often well preserved; and it is to be remarked that these two fossils occur in the same geological position in the Undercliff of the Isle of Wight.

The relations of the Malm-rock are no where better exhibited than in the vicinity of Binsted, Hants. The peninsular terrace upon which that village stands, is composed exclusively of this formation, which projecting nearly 3 miles beyond the Alton chalk-range from south-west to north-east, is surrounded at its base on three sides by the subjacent Gault. The Malm-rock is cut through by the river Wey, which thus separates the promontories of Binsted from those of Froyle and Bentley *.

There exists a remarkable analogy between this inland range, and that laid open in the coast-section of the Undercliff in the Isle of Wight. The Malm-rock at Hawkley, like that of the Undercliff, forms a terrace terminated by a

* The Malm *Rock* of Sussex and Hants must be distinguished from the Malm *Land* of Surrey at the base of the North-downs, east of Box Hill; the latter being an agricultural term for the black clay belonging to the Gault.

mural escarpment, having its crest and base fringed with foliage, and resting upon a green talus of Gault. This base of clay after the wet winter of 1774 (see White's Hist. of Selborne, letter 45) gave way under the superincumbent pressure, occasioning the well-known Hawkley Slip, by which houses and barns were displaced or thrown down. The surface of the Gault was rent into fissures, and a large portion of the debris of the Malm-rock was ingulfed. The subsidence of the Gault between Luccombe and Bonchurch, in the Isle of Wight, has more recently occasioned a similar fall of the Undercliff.—It may be stated, as an inducement to the traveller to diverge from the high road into this district, that the deep and woody glens which intersect the escarpment of the Malm-rock, offer the most picturesque varieties of landscape.

II. *Gault.*

Below the range of the Malm-rock is seen a continuous breadth of Gault. This stratum is most clearly developed at the north-eastern angle of the district; where it forms the valley under Bentley and Binsted, and then rises into eminences which compose the forest of Alice Holt. The superior bed is commonly a brown or yellowish clay; but on penetrating a few feet, blue harsh clay is reached, which generally effervesces with acids, and appears to be of uniform character throughout, in the deepest sections. On the surface of Alice Holt there is frequently a diluvial covering of red and yellow flints, which in some places is from 12 to 14 feet thick; and where this occurs, water has been procured by sinking merely through this gravel; whilst in other parts, the subjacent blue clay has been penetrated to the depth of 40 feet unsuccessfully. Of the fossils of this formation I have met most frequently with the *Ammonites dentatus,* at 6 or 8 feet below the surface. The junction of the Gault with the Lower Green-sand is clearly exposed at the south end of the village of Wracklesham, where the superior beds of the latter formation are similar to those, of which specimens have been brought up by boring through the Gault near Cambridge, and which are now in the museum of the Society.

The agricultural character of this clay is unvaried in its whole extent from Wracklesham near Guildford to the river Arun in Sussex. Its line is marked by the most fertile water meadows and the finest forest timber; thus presenting a *green* belt, which clearly defines and distinguishes it from the rich wheat land of the Malm-rock above, and the arid expanse of the Lower Green-sand below.

III. *Lower Green-sand.*

The Lower Green-sand is the most extensive formation in this district, and presents an undulating and unequal surface. It rises from the valleys of Gault,

and swells into hills, which increase in elevation as they recede from the incumbent strata, and finally attain a height equal to the most lofty points of chalk in the range of the South-downs.

The beds dip every where towards the chalk, but in the south-eastern part of the district more rapidly than in the north-western. They are inclined towards the Alton chalk-hills at an angle which is scarcely perceptible, and accordingly in that quarter are expanded over a more considerable extent of surface than towards the South-downs, where the dip frequently amounts to 10 or 15 degrees.

Woolmer Forest, Petersfield, Haslemere, Midhurst, and Petworth are in this formation.

The superior beds consist of quartzose grains combined with oxide of iron; and they abound in veins of iron-stone, which are occasionally hollow and of large dimensions, at other times compact. The colour of the sands in this part of the formation is very varied: in some places, as near Rogate, deep sections occur of a pure white sand; whilst in Woolmer Forest and at Frensham the mass is dark red, with many veins of contorted and cellular iron-stone.

A bed of calcareous grit appears to occur uniformly along the centre of this formation, and may be traced from Godalming through Headley, Lyss, Rogate, Stedham to Dean Farm near Petworth. At the latter place it is a compact blue limestone, and is extensively quarried for the roads; but in the former situations, the grit is a conglomerate of quartz grains and pebbles, bound together by a strong calcareous cement, and is called *Bargate Stone**;—it is hard and durable, and has recently been burnt for lime.

Towards the lower part of the sands, gray and blue chert occurs, particularly at Iping Hammer-ponds, Brinksole Heath, &c. &c.

The lowest beds are marked by a great change of appearance;—green particles are now intimately mixed throughout the mass, and all the hills which immediately adjoin the valley of the Weald clay, afford a yellowish sandstone filled with green particles, which is used for building, and is the only bed of this formation west of the river Arun, which I have observed to contain fossils, or rather the casts of them †. These casts appear to be of Ammonites and Terebratulæ, but were not sufficiently perfect for Mr. Sowerby to distinguish the species.

* Mr. Greenough informs me that this calcareous grit extends eastward thoughout the same formation in Surrey and Kent, where also it is known by the name of *Bargate Stone*.

† Parham Park is in this formation; but being west of the river Arun, the consideration of the fossils found there is not now entered upon.—Those however which I have seen from that place, are very unlike the casts to which I now allude.

The best quarries of this rock are north of Midhurst, as at Dunner Hill, Pit's Hill, &c. &c.

It is worthy of remark that this formation, though not retentive of water, supports a vast number of small lakes or ponds. Those of Frensham, Woolmer Forest, Petersfield, Iping and Burton are examples.

The river Wey (the principal branch of which rises in the chalk at Alton from numerous and perennial springs), after flowing through the chalk, the Malm-rock and the Gault successively, has its course exclusively in this stratum for about 20 miles, until it turns to intersect the chalk-escarpment at Guildford. In like manner the Rother, or western branch of the river Arun, which rises in the chalk and flows over the intermediate formations, is in its subsequent course confined to these sands ; passing near Lyss, Petersfield, and Midhurst, to its junction with the main branch at Pulborough.

The depth of the wells in this formation increases with the rise of the hills. At Petersfield water is reached in 20 or 30 feet ; at Rake common, in 200 feet ; and in boring for water this summer at Petworth-house, near 400 feet of sand were passed through, when a blue clay was brought up which effervesced with acids.

Diluvial accumulations of chalk flints sometimes occur on the surface of these sands, as at Rogate Common, &c. and several beds of such debris were cut through last summer near Trotton, in making the new road from Petersfield to Midhurst. Their presence on this stratum is worthy of remark, as I have never met with them on the subjacent formation of Weald clay.

IV. *Weald Clay.*

The Weald clay, which is next in the series, forms at Harting Combe the nucleus of the western part of this district.—The line A B on the map, drawn from this point west-by-north and south-south-east, shows a section complete in all its members up to the chalk escarpment on either side.

The passage from the lower green-sand to the clay is well observed along the base of the hills which bound the valley on the south, where very thin beds of various-coloured clays alternate with soft dark green-sand. These striæ seem to mark the dip, which is at an angle of from 10 to 12 degrees.

The surface clay in the bottom of the valley is yellowish-brown in colour ; but changes below to a deep red, and is then highly impregnated with oxide of iron.

The general form of the valley in this part of the Weald is peculiar, and the great inequality of its width is a striking feature in the geological map.

From its western angle and commencement at Harting Combe, little more

of it is seen to the east, for 7 or 8 miles, than a narrow gorge, which is flanked, on the north, by the lofty hills of Blackdown, and on the south, by the corresponding ridge extending from Holder and Bexley hills to near Petworth. The valley is then suddenly expanded to three times its former breadth by the retirement at a right angle of the sand-escarpment of Blackdown and Haslemere.

In the extensive vale thus laid open the best specimens of the Sussex or Petworth marble are found. The disintegrated beds near the surface afford the characteristic Viviparæ in abundance, whilst in the more compact masses the *Cypris Faba* may also be discovered. The different localities of this marble are given in the annexed table of the order of superposition : but it may be remarked that the parish of Kirdford contains some of the largest and finest slabs.

Iron-ore is much disseminated through this formation, as well as through the inferior formation of Hastings or Iron Sand.—The Weald clay abounds in ancient iron-works, and their sites are still to be traced from near the junction of the lowest beds with the Hastings sand, up to the highest beds at the base of the lower green-sand. In the gorge of Harting Combe, at Lynch, Redford, &c. &c., the slag of the extinct furnaces is yet used as a material for repairing roads. These places are situated from 10 to 12 miles west of the outcrop of the iron-sand.

V. *Hastings or Iron Sand.*

This lowest formation of the vale of Sussex rises in gentle undulations immediately to the east of Kirdford in the parish of Wisborough Green, where, at Headfold-wood Common near Loxwood, its outline makes an angle, corresponding to that formed by the Weald clay and the superior strata.

Although these beds at their first emergence consist chiefly of clay, yet they differ essentially from the Weald clay in containing near the surface small flags of a slightly *calcareous sand-stone*, and beneath these, large tabular masses of a calcareous grit, which is very similar to certain beds of the Stammerham and Slinfold quarries west of Horsham. Unlike, however, to the latter, the calcareous grit-stone of Wisborough Green is based upon a deep mass of red ferruginous marly clay, and is only found in detached portions.

The Horsham beds have already been well described by Mr. Lyell, in a letter addressed to Mr. Mantell and read at the Geological Society, and have been examined by Mr. L. at Stammerham; but their extension to Skiff Common and Loxwood, from 9 to 10 miles west of that place, has not previously been noticed.

I have now the satisfaction of laying before the Society numerous fossil remains of large vertebrated animals from two localities at the extreme

western angle of this formation, where the inhabitants have occasionally found similar remains for many years. Their occurrence to the eastward, however, appears to be very partial. In the extensive quarries of Stammerham I could only discover that one vertebra had been seen (apparently that of a tortoise); whilst in the intervening tract of 9 or 10 miles between that place and Loxwood, no analogous remains have been met with, although numerous quarries of the same tabular grit-stone are worked at Slinfold, Billingshurst, &c. &c.

The greater number of the bones now presented, were found at Headfold-wood Common, in 1824; they were situated about 5 feet below the surface: above them the mass was yellowish-brown clay, with micaceous sandstone occurring occasionally; and below the clay were large tabular masses of the calcareous grit. Immediately beneath this stone the bones were impacted in ferruginous and marly clay; under this were veins of blue clay, containing selenite.

The largest specimen proves to be a femur*. It measured, when entire, 3 feet 7 inches in length. (See Pl. XV. fig. 9.) One vertebra (No. 8) and many large fragments of bones were also found here.

Recently J. King, Esq. of Loxwood, has met with many more osseous remains imbedded in the clay north of his house, and about 3 feet from the surface. By his kindness I am now enabled to present a series of vertebræ and other specimens to the Society. (See Pl. XV. fig. 1 to 7.)

Mr. Clift, of the College of Surgeons, obligingly examined these remains. He finds that they possess the striated texture of surface which characterizes the bones of fishes, crocodiles, and aquatic saurians; and that the thin wall or exterior crust, which covers an interior cancellated structure, further establishes his conclusion, that they have belonged to some great aquatic animal.

Having submitted the drawings and some of the specimens to Baron Cuvier for inspection, I have been favoured by him with the following remarks. "I am inclined to believe," he observes, "that they are the remains of a *new* species of large saurian; since I am not acquainted with any thing similar to them amongst either recent or fossil reptiles: nevertheless, as Mr. Mantell has not yet found (that I am aware) the different parts of the skeleton of the Iguanodon, and since the formation in which these new bones occur, appears, from your account of it, to be a continuation of that of Tilgate Forest, I think it not impossible that some of these bones may have belonged to that animal. I can safely affirm that the vertebræ now submitted to me are not those of Plesiosaurus; but whether any of these remains did or did not belong to the

* This femur is in the possession of I. Napper, Esq., of Ifold, who politely sent it to the Geological Society for inspection.

Megalosaurus, the specimens of that animal in my possession are too few to enable me to decide. All that I can state is as follows. The vertebra No. 8, found near the great femur, does not appear to be of the same species with the others. No. 2 is probably a lumbar vertebra. No. 4 may be a sacrum. Nos. 1, 3, and 6, are certainly caudal vertebræ. No. 6, which (as you will observe) consists of two united into one, is remarkable for presenting an anchylosis of two caudal vertebræ: and No. 6 was disposed to become anchylosed to No. 3. I have just examined all my skeletons of reptiles, and have not found any analogous case, except when the tail has been broken; and then the bones become united by exostosis, which is not the case with these specimens. Hence it would seem, that this must have been an animal making such feeble use of the tail, that the caudal vertebræ were occasionally anchylosed together. No. 3 is one of the first caudal vertebræ, *viz.* of those which support the largest chevron-shaped bones; for the articular tubercles of these bones are very strongly marked upon it. No. 11 (not here figured) is the articular apophysis of a vertebra. Nos. 5 and 10 (not figured) are probably portions of ribs. As to No. 7, the rugosities of its two extremities, which evidently terminated upon cartilage, indicate that it did not belong to a limb; and it can therefore only have been either a false rib or a branch of the os hyoides."

Before receiving the preceding communication from Baron Cuvier, through the kind assistance of Mr. Mantell I had compared these remains with the bones from Tilgate Forest found in the same formation; but as no teeth or specimens sufficiently marked and *peculiar* have yet been met with at Loxwood, I was not able to establish any case of identity between the bones from these two localities.

The vertebræ are of a very uncommon form, being highly contracted in the middle with sharp angular sides; and of their two extremities, the one is nearly *flat*, the other concave: hence it appears probable that they are not referrible to the Iguanodon of Mr. Mantell, nor to any of the hitherto discovered saurians of Tilgate Forest.

In concluding the geological view of this district, I beg to observe, that if Loxwood be taken as a centre, a section to the south presents a similar succession of strata to that which is developed on either side of Harting Combe, with the addition in the former case of the iron-sand. The river Arun, in its course from the Weald, passes through the lower green-sand, the gault, the malm-rock, and the chalk of the South-downs; whilst a section to the north, exposes principally the green-sand, between which and the chalk of the Hog's Back the intervening formations are reduced almost to imaginary lines.

Appendix I.

Order of Superposition.

Formations.	*Subdivisions and Varieties.*	*Localities.*
Chalk	. . . . .	South-downs, Alton Range, &c.
A. Fire-stone or Upper Green-sand, provincially termed *Malm-rock*	Malm-rock	In all the terraces under the chalk.
	Compact blueish building-stone .	Froyle and Binsted, Hants. Sutton in Sussex.
	Fire-stone	Selborne, &c.
	Fossils abundant at	Nursted, Harting, Hawkley, &c.
B. Gault	Upper beds stiff brown clay . .	Alice Holt Forest, Steep, Down Park, Elstead and Minsted Marshes, &c.
	Lower beds dark blue harsh clay containing Ammonites, &c. .	
C. Lower green-sand, Car-stone, or Shanklin Sand	Quartz grains with oxide of iron .	Petersfield, Turwick, &c.
	Pure white sand with delicate ferruginous veins	Sand-pits south of Rogate.
	Iron-stone, cellular, in large tubes	Road east of Cowdry Park.
	Compact iron-stone	Woolmer Forest, &c.
	Calcareo-siliceous grit: Bargate-stone	Hedley, Lyss, Trotton, Stedham, and Half-way Bridge between Midhurst and Petworth.
	Blue fine limestone grit	Dean Farm, Petworth.
	Sand-rock passing into chert . .	Iping Ponds, Brinksole Heath, &c.
	Siliceous yellow building-stone with green particles; . . .	Dunner Hill, Pit's Hill, and
	And containing casts of Ammonites, Terebratulæ, &c. . . .	Range north of Midhurst.
D. Weald Clay . . .	Yellowish brown clay, red below with argillaceous iron-ore . .	Harting Combe, Redford, &c. Extinct Iron furnaces, &c.
	Yellowish brown clay, containing compact Petworth marble . .	Kirdford, Palfreys, Battlehurst Glass-house, Spar Wood, &c.
E. Hastings or Iron-sand	Calcareous sand-stone in clay, with disintegrated Viviparæ: tabular calcareous grit with *bones of large vertebrated animals* .	Headfold-wood Common, Loxwood, Wisborough Green, Skiff Common, &c.
	Deep red clay below with argillaceous iron-ore	
	Lowest bed: courses of blue clay with Selenite	

Appendix II.

Quantity of Calcareous Matter in some of the Rocks mentioned in the preceding Paper.

Malm-rock . .	from Hawkley Slip, yellowish	20 per cent.
	. . Nursted grayish	21
	. . Ditto brown	19
	. . Bentley blue, compact	34
Bargate Stone .	from Lyss	66
	. . Godalming	68
Iron Sand . . .	Grit from Slinfold	34
	. . . . Cuckfield, road-stone	24
	. . . . Loxwood, above the bones	29

X.—*On the Chalk and Sands beneath it (usually termed Green-sand) in the Vicinity of Lyme Regis, Dorset, and Beer, Devon.*

By H. T. De la BECHE, Esq. F.R., L. and G. S.S., etc.

[Read December 16th, 1825.]

In presenting an account of the manner in which the above rocks occur in the vicinity of Lyme Regis and Beer, I by no means wish to engage in the discussion which has arisen respecting *Green-sand;* but merely to describe the rocks, as they exist in that neighbourhood. At the same time, I consider it as much to be regretted, that some general term is not given to the sands, marls, and clays which occur beneath the Chalk, as has been done in the case of the Oolite formation: the various parts might then be distinguished by different specific names, and there would be no more impropriety in grouping the Green and Ferruginous sands together, than in uniting under one term the various members of the Oolite formation, and distinguishing them by the names of Great and Inferior oolite, Kimmeridge and Oxford clays*, &c. Some such arrangement as this would prevent much uncertainty: for at present when the term Green-sand is used alone, without further distinction, we may be led to confound two different things. Moreover, we are in want of a general appellation by which to denote these rocks collectively; for we are not to suppose that all the small divisions that may be made in this collection of sands, marls, and clays in the east of England, can be traced into other and distant countries, where, however, the sands, &c., as a mass may be easily recognised. This cannot be done even in comparatively small distances, as will be seen in the district which I am about to notice; since the sands come together, and seem more or less to pass into each other; while the marls and clays, found among them in the east of England, have disappeared.

The cliffs near Lyme Regis and Beer afford ample opportunities for examining the Chalk and the sands beneath it, usually termed *Green-sand,* and there

* Some such name as the Glauco-ferruginous Sand formation might perhaps be applicable;—part of it has already been termed *Glauconie Crayeuse,* by M. Brongniart.

is no difficulty in determining the order in which they occur. For the portions of the cliffs composed of these rocks, I must refer to my section of this coast contained in the Geological Transactions, vol. i. second series, Pl. VIII.; and for a detailed section of their relative position, to Pl. XVI. which accompanies this paper. I shall in the first instance, for the sake of convenience, notice the Chalk and the sands beneath it near Lyme Regis, and then proceed to those near Beer.

Chalk near Lyme Regis. (Pl. XVI. fig. 1.)

This Chalk may be divided into Chalk with flints, Chalk without flints, and Chalk with quartz-grains; and is, taken as a mass, about 190 or 200 feet thick, where most developed at Pinhay and Dowlands cliffs.

Chalk with flints.—This, as usual, constitutes the upper part of the formation, and is about 150 feet thick at Dowlands. For about 100 feet from the top, the flints are very numerous, and in layers, occasionally mixed with continuous seams of the same substance. In its lower part, the flints become more rare, gradually losing the appearance of being distributed in layers, and finally occur as detached pieces, without order, in the mass of chalk. The organic remains that usually occur in this division of the Chalk, are so well known, that it would be useless to enter into a detail of them; they have not been found very abundantly in this neighbourhood; but such as have been discovered, correspond with those contained in the same division of the Chalk in the east of England.

Chalk without flints.—This division succeeds to the above, the flints becoming gradually scarce, and in the end disappearing altogether:—in the neighbourhood I am noticing, it is in general tolerably hard, and does not exceed 30 or 40 feet in thickness. The most abundant organic remains contained in it are the *Catillus Cuvieri* of M. Brongniart, Env. de Paris*, Pl. IV. fig. 10, (the *Inoceramus Cuvieri* of Sowerby), and the *Mytiloides labiatus* of M. Brongniart, Env. de Paris, Pl. III. fig. 4, (the *Inoceramus mytiloides* of Sowerby, tab. 442). The palates, scales, and teeth of fish are also found in it, with Belemnites, and the *Ostrea vesicularis* of Lamarck. (Env. de Paris, Pl. III. fig. 5.)

Chalk with quartz-grains.—This division gradually acquires small irregugularly rounded grains of white quartz, and ends by becoming thickly studded

* I use this abbreviation for the *Description Géologique des Environs de Paris,* par MM. G. Cuvier et Alex. Brongniart, contained in the 2d part of the 2d vol. of Cuvier's *Ossemens Fossiles.*

with them, and thence acquiring considerable hardness. It is difficult to say whether these grains have been mechanically rounded by attrition against each other, previous to their envelopement in the Chalk, or whether they are of contemporaneous origin with it;—it is however most probable that they are of mechanical origin. The thickness of this division is about 20 or 30 feet, and at the bottom of it there is a very hard compact bed, about 3 feet thick, in which the quartz and siliceous matter greatly predominate, giving to the whole a very siliceous character. This bed is of a browner tint than the Chalk above it, and may thus be easily recognised in Pinhay, Whitelands, Charlton, Rusedon, and Dowlands, the separation between the two being rather marked as to colour. This bed, for the present, I class with the Chalk containing quartz-grains, as it agrees more with that than with the sandstone beneath it;—the surface of the bed next to the Chalk with quartz-grains, contains numerous organic remains, which, with those contained in the whole of this division, are as follows:

Palates and teeth of fish.

An Encrinite.

Alcyonia.

Echinites.

Cidarites variolaris . . . . . A. Br. (Env. de Paris, Pl. V. fig. 9.)
——— (another species, not determinable).
Echinus areolatus . . . . . Wahlenb. This appears to be the E. Leucorhodion of Mr. König's arrangement in the British Museum.
Galerites vulgaris . . . . . Lam.
——— albo-galerus . . . Lam. (Env. de Paris, Pl. IV. fig. 12.)
Nucleolites depressa . . . . A. Br. (Env. de Paris, Pl. IX. fig. 17.)
Ananchytes hemispherica. . Lam. (Env. de Paris, Pl. V. fig. 8.)
Echinonaus lampas . . . . . De la Beche (Geol. Trans. 2d series, vol. i. Pl. III. fig. 3, 4, 5.)
Spatangus cor anguinum . . (Env. de Paris, Pl. IV. fig. 11.)
——— lævis . . . . . Deluc. (Env. de Paris, Pl. IX. fig. 12.)
Spines of Echinites by no means rare.

Chambered Univalves.

Nautilus	(2 species.)
Ammonites varians	Sow. (Min. Con. Tab. 176.)
———— rhotomagensis .	Defr. (Env. de Paris, Pl. VI. fig. 2.)
———— Coupei	A. Br. (Env. de Paris, Pl. VI. fig. 3.)
———— constrictus . . .	Sow. (Min. Con. T. A.)
Scaphites	
Turrilites Bergeri	A. Br. (Env. de Paris, Pl. VII. fig. 3.)
Belemnites.	

Univalves.

Trochus Gurgitis	A. Br. (Env. de Paris, Pl. IX. fig. 7.)
———? Rhodani	A. Br. (Env. de Paris, Pl. IX. fig. 8.)

Bivalves.

Cucullæa carinata	Sow. (Min. Con. T. 207. fig. 1.)
Trigonia aliformis	Sow. (Min. Con. T. 215.)
Pachymya *	Sow.
Plicatula.	
Gryphæa columba	Sow. (Min. Con. T. 383.)
Ostrea vesicularis	Lam. (Env. de Paris, Pl. III. fig. 5.)
Terebratula subrotunda . .	Sow. (Min. Con. T. 15. fig. 1, 2.)
———— plicatilis	Sow. (Min. Con. T. 118. fig. 1.)

Sands and Sandstones beneath the Chalk near Lyme Regis.

These may, for the convenience of more easy description, be divided into three parts, viz. yellowish-brown Sandstone with chert-seams; yellowish-brown Sand (commonly called "Fox Mould" by the people of the country); and Sands and Sandstones containing an abundance of green-earth, from which circumstance the term *Green-sand* has been very generally applied to the whole of the above sands and sandstones in this district;—these taken together constitute a thickness of nearly 200 feet.

Yellowish-brown Sandstone with chert-seams.—This division commences immediately beneath the very compact bed, mentioned under the head of Chalk with quartz-grains. The upper portion of this Sandstone, for the thickness of 12 feet, does not contain the chert in regular seams, but merely in detached pieces; here and there we observe portions of green-earth, with thin veins and specks of oxide of iron. This upper portion contains the teeth, vertebræ and

* This new genus has been figured in T. 504 and 505 of Sowerby's Mineral Conchology.

scales of fish, the spines of Echinites, and a quantity of broken shells, among which, pieces of Pectens and Oysters are distinguishable. To this succeeds a very compact and yellowish-brown siliceous sandstone with regular chert-seams, which are in general several inches thick, and afford very fine specimens of chalcedony. In this sandstone, organic remains are by no means well preserved; on the contrary, the shells most frequently occur much broken, the fragments being arranged in layers parallel to the chert-seams. The *Chama digitata*, Sowerby, (Min. Con. T. 174.) is not an uncommon fossil in this division; and the *Spatangus ornatus*, Defr. (Env. de Paris, Pl. V. fig. 6.) is to be found in the chert. The whole of this division is from 70 to 80 feet in thickness, and can be well studied in Ware Cliffs, the western side of Pinhay, at Whitelands, Charlton, and Dowlands.

Yellowish-brown sand (Fox mould).—This division is about 70 or 80 feet thick, and consists principally of a yellowish-brown sand of various shades of colour, acquiring, however, green-earth as it approaches the next-mentioned division, into which it seems to pass. This sand can be best studied at the fine section obtained at the new road between Lyme Regis and Charmouth, where a deep cut has been made in it at the top of Black Ven. Organic remains are extremely rare in it, a few scattered fragments only of shells having been yet discovered; in this respect, it differs very widely from the next division.

Sand and Sandstone containing an abundance of green-earth.—This in fact may be fairly called a Green-sand, being almost wholly of that colour, and is principally composed of a mixture of green-earth and siliceous sand. It abounds in organic remains, contains indurated nodules and seams (commonly called Cow Stones) in its lower part, and is about 40 or 50 feet in thickness. Some portions of this green-sand, when exposed to wet, have rather a clayey character, and the indurated nodules sometimes contain mica, and thin veins of calcareous spar.

The organic remains, which are in general well preserved, and sometimes converted into chalcedony, are as follows:

Impressions of Ferns.

Crustacea*.

Pieces of a bony substance.

Alcyonia.

* The most common fossil of this kind presents us with several points of resemblance to the genus Astacus. It measures generally from 4 to 6 inches in length, not including the claws, and has as yet been only found in the indurated portions, or *Cow Stones.*

Echinites.

Spatangus cor anguinum . . . (Env. de Paris, Pl. IV. fig. 11.)
——— suborbicularis . . . Defr. (Env. de Paris, Pl. V. fig. 5.)
Enanchytes hemispherica . . Lam. (Env. de Paris, Pl. V. fig. 8.)

Chambered Univalves.

Nautilus simplex . . . . . Sow. (Min. Con. T. 122.)
——— elegans . . . . . Sow. (Min. Con. T. 116.)
Ammonites Beudanti . . . . . A. Br. (Env. de Paris, Pl. VII. fig. 2.)
——— Goodhalli . . . . . Sow. (Min. Con. T. 255.)
Hamites.

Univalves.

Vermicularia . . . . . Lam.
Melania.
Auricularia incrassata . . . . Sow. (Min. Con. T. 163. fig. 1, 2, 3.)

Bivalves.

Mya mandibula . . . . . Sow. (Min. Con. T. 43.)
Lutraria? Gurgitis . . . . . A. Br. (Env. de Paris, Pl. IX. fig. 15.)
Venus.
Astarte.
Cardita tuberculata? . . . . . Sow. (Min. Con. T. 143.)
Cucullæa glabra . . . . . Sow. (Min. Con. T. 67.)
——— costellata . . . . . Sow. (Min. Con. T. 447. fig. 2.)
Arca carinata . . . . . Sow. (Min. Con. T. 44, lower figure.)
Trigonia scabra . . . . . Lam. (Env. de Paris, Pl. IX. fig. 5.)
——— aliformis . . . . . Sow. (Min. Con. T. 215.)
——— spinosa . . . . . Sow. (Min. Con. T. 86.)
Chama.
Plagiostoma Mantelli . . . . (Env. de Paris, Pl. IV. fig. 3.)
Pecten quinquecostata . . . . Sow. (Min. Con. T. 56.)
——— asper . . . . . Sow. (Min. Con. T. 370.)
——— orbicularis . . . . . Sow. (Min. Con. T. 186.)
Podopsis truncata . . . . . Lam. (Env. de Paris, Pl. V. fig. 2.)
Gryphæa obliquata . . . . . Sow. (Min. Con. T. 112. fig. 3.)
Ostrea carinata . . . . . Sow. (Min. Con. T. 365.)
Terebratula biplicata . . . . . Sow. (Min. Con. T. 90.)
Inoceramus concentricus . . . Sow. (Min. Con. T. 205.)*

* The reader, after perusing the above list, cannot but be struck with the circumstances, that the fossils in this division closely correspond with the celebrated siliceous fossils from Blackdown, which are probably also contained in the same division.

Having thus described the chalk and the sands beneath it, as they occur between Lyme Regis and Axmouth, I shall now proceed to notice the same rocks as they are exhibited in the vicinity of Beer, Devon. Ample opportunities are afforded for studying the developement of the chalk, &c. at the latter place, in the cliffs on both sides the village. In order, however, to understand the changes which the various portions undergo, it will be necessary to commence with the section afforded by White Cliff, between Beer and Seaton. (Pl. XVI. fig. 2.)

Chalk of White Cliff, Beer.

This rock is developed much in the same way as in the vicinity of Lyme Regis, with the exception that the lowest part of the *Chalk without flints* does not become studded with quartz-grains, though the compact bed, abounding in organic remains, is still seen beneath it. The latter is from its hardness very conspicuous, and may be seen at low water, forming a ledge of rocks that extend into the sea to the eastward of the village, making a basin-shaped curve, and again rising towards the line of cliffs that extend to Beer Head. Near the village this bed is not so thick as in the vicinity of Lyme Regis.

Sands and Sandstones beneath the Chalk at White Cliff.

A glance at the sections (Pl. XVI. fig. 2 and 3.) will show, that though the general mode of occurrence of these rocks is the same as that in the vicinity of Lyme Regis, yet there are parts which at other places are more or less developed. Commencing immediately beneath the compact and siliceous bed above noticed, we have the upper portion of the sandstone with chert-seams much thicker than at Pinhay, Whitelands, &c. At the latter place it was of no great importance; but here it has swollen out, and forms a much more conspicuous part of the section, containing at the same time more green-earth. The following is a section (Pl. XVI. fig. 2, 3.) of this rock and of the yellowish-brown sandstone with chert-seams, into which it passes.

1. Yellowish-white sandstone.
2. Nodules of compact light-coloured sandstone, connected together by sandstone containing green-earth.
3. Yellowish-brown sandstone containing chert-seams.
4. Yellowish sandstone with some green-earth, and numerous quartz-grains.
5. Nodules of chert in yellowish-brown sandstone.

6. Sandstone abounding in green-earth, intermixed with nodules of light-coloured sandstone.
7. Yellowish-brown sandstone with chert-seams.
8. Large-grained sandstone, containing the teeth and vertebræ of fish, with broken shells, &c.
9. Yellowish-brown sandstone with chert-seams.

To these succeed sands of a greenish-yellow or brown colour, which are equivalent to the yellowish-brown sands (commonly called Fox mould) of the vicinity of Lyme Regis: they here, however, contain much more green-earth, and inclose (which they do not at Lyme Regis) several nodules of chert. The various shades of colour are also more conspicuous in the upper parts than at the latter place.

To this, as at Lyme Regis, succeed sands abounding in green-earth, and containing the same fossils and the same indurated portions as at that place; there seems, however, to be more iron-pyrites in those of Beer. The whole of the above sands and sandstones pass into each other.

The above section shows the manner in which the Chalk and the Sands beneath it occur on the eastern side of the Beer basin; the following will exhibit the changes these rocks have undergone on the western side.

Chalk, with the Sands and Sandstones beneath it, at Branscombe and the Beer Quarries.

The principal information to be derived from these, is the position of the Beer stone, which, whether it belongs to the chalk or to the arenaceous rocks beneath, it is difficult to say.

At Branscombe Cliffs, to the westward of Beer Head, we have the best exposure of the rocks above and beneath the Beer stone. The latter has been quarried by sinking a shaft from the top of the hill, and then driving a level to the face of the cliff, which thus presents a large cave-like aperture.

The Chalk-without-flints, and the Chalk-with-flints, which together attain the thickness of 200 feet near Beer Head, can be seen to rest upon the Beer stone, which in its turn rests upon a light-coloured compact sandstone, containing a considerable portion of green-earth; but exhibiting in its upper portions ferruginous parts;—beneath this we have the yellowish-brown sandstone with chert-seams.

At the quarries, situated about half a mile or more from the village of Beer, the Beer stone itself can be best studied. This stone appears to have been

worked for ages, as old buildings and the state of the quarries testify. When first quarried, it is somewhat soft and easily worked, but becomes harder by exposure to the air; it is nearly white, and principally composed of carbonate of lime, with small brilliant facets, which also appear to consist of carbonate of lime partially disseminated through it: it contains also some argillaceous and siliceous matter, and very thinly sprinkled specks of green-earth*.

The quarry itself is interesting as a cavern, and affords a miniature representation of the Maestricht quarries; the roof, which is nearly even and parallel to the floor, being supported by large square pillars. The depth of this cavernous quarry from the entrance is about 170 yards. The workmen enumerate the following beds, beneath 18 feet of indurated chalk without flints, which they call *Skull*.

1. Upper bed,—eighteen inches thick, rather hard.
2. Eighteen inches thick, soft.
3. Two feet thick, rather soft.
4. Two feet thick, rather soft.
5. Sixteen inches thick, hard.
6. Sixteen inches thick, mixture of hard and soft.
7. Eight inches thick, very hard.
8. Two feet thick, very hard.

Beneath these are about 5 or 6 feet of a hard white calcareous rock, which burns into good lime, but is not quarried as the others are. Beneath this the sandstones commence.

From what has been above stated, it appears that considerable changes take place in rock-formations even in short distances: as for instance, the remarkable bed with quartz-grains, though so conspicuous at Pinhay, Whitelands, and Dowlands, fines off at White Cliff, near Beer, and is no longer visible at Branscombe: on the other hand, the Beer stone of Branscombe and the quarries is not found even at so short a distance as White Cliff; and therefore we ought not to be surprised at not finding it at Dowlands, Whitelands, &c. The chalk at the latter places contains quartz-grains in its lowest part; whereas at Beer the same part of the chalk contains none, if we except the remarkable bed above mentioned. The Fox mould near Lyme Regis, does not contain so much green-earth as at Beer, and few, if any, nodules of chert. The sand-

* It seems to me probable, that the Beer stone is the equivalent of the Malm-rock of Western Sussex and the South-east of Hampshire, described by Mr. Murchison, and of the Merstham Firestone of Mr. Webster.

stone also, between the chalk and the sandstone with chert-seams, is much more developed at Beer than at Lyme Regis, and contains much more green-earth. If, therefore, in rocks formed at the same geological epoch, variations such as are here noticed, occur within the space of a few miles, how many points of difference may we not expect to find in geological equivalents, belonging to countries many thousand miles apart!

XI.—*On the Formation of the Valley of Kingsclere and other Valleys by the Elevation of the Strata that enclose them; and on the Evidences of the original Continuity of the Basins of London and Hampshire.*

By the Rev. W. BUCKLAND, S.T.P. F.R.S. F.L.S.

PRESIDENT OF THE GEOLOGICAL SOCIETY, AND PROFESSOR OF MINERALOGY AND GEOLOGY IN THE UNIVERSITY OF OXFORD, ETC.

[Read February 8th, 1825.]

It may be seen, on referring to Mr. Greenough's Geological Map of England, and to the map annexed to the paper of Mr. Webster on the Basins of London and Hampshire, that the tertiary formations which occupy the basin of London, become gradually contracted in their progress westward through Berkshire, until they terminate in a point at Savernake Forest, between Hungerford and Marlborough. The strata of chalk, on which these formations repose, dip inwardly from the circumference towards the axis of the basin, and sink, nearly on all sides, beneath overlying beds of the Plastic and London clays.

A remarkable exception, however, to this arrangement occurs near the south-western extremity of the basin, a few miles to the south of Newbury, at Kingsclere and Highclere. It is the chief object of the present communication to describe the appearances attending this exception, and to point out some general conclusions with respect to the origin of certain valleys from the elevation of the strata that now inclose them. The observations on which this paper is founded, were made principally during a visit in the summer of 1819 to the Earl of Carnarvon at Highclere. I had then an opportunity of carefully surveying the ground in question, which I had viewed hastily some months before on a journey through the district in company with Mr. Greenough and Mr. Warburton. But for the more minute details of the limits of the several formations, as they wind along the south-western border of the basin, I am indebted to the exertions of an eminent botanist, Mr. J. R. Gowen of Highclere.

The red lines on the map, extending from the village of Inkpen to Highclere, mark the southern and south-western outcrops of the formation of Plastic clay, as displayed on the surface at several interrupted points, and as used in many places for brick-earth. It presents the same irregular alternations of brick-red, mottled, and occasionally blackish clay with loam, sand and rounded chalk-flint gravel, which occur in this formation at Reading, Blackheath, and wheresoever else it presents itself within the basins of London and Hampshire. Occasionally also, as at Kintbury on the west of Newbury, it contains the same organic remains, in the same state of preservation, as in the well-known clay-pits at Reading; viz. oysters, sharks' teeth, &c In the blacker beds of clay there is abundance of vegetable matter and wood, constituting the same kind of imperfect brown-coal that attends this formation at Blackheath, Alum Bay, and Corfe Castle. The lowest stratum of the formation, or that next above the chalk, consists, in this instance also, for the most part of sand; and at its actual contact with the chalk, is often loaded with flints, which are coated superficially with either a green or brown rusty crust. The sand is fine and siliceous, and is interspersed, as usual, with particles of green-earth.

Into this western and uppermost extremity of the great chalk-basin of London, the London clay penetrates to a considerable extent, the limits of which clay it is foreign to my present purpose to investigate; whilst the greater number of the minor hills round Newbury are composed of loamy sands and clays of the Plastic formation, occasionally denuded, in the valleys, down to the subjacent chalk. Several extensive plains that still remain in heath and commons, are composed of extremely sterile sand-beds, more or less mixed up with gravel*.

* The following observations on the gravel of this district are extracted from a letter to the author by J. R. Gowen, Esq. of Highclere.

"It is almost impossible to define the relative quantities of gravel and clay in the vale of Newbury. Nothing can be more irregular than their distribution, though in general it may be assumed, that in the commons, such as Newbury, Greenham, Crookham, Sidmonton, Burghclere, Aldermaston, Mortimer, &c., gravel, covered with a very shallow stratum of black sandy soil, greatly predominates. This black sand is of the most sterile nature, bearing nothing but heath, and a few of the worst species of grass, scattered in thin patches at large intervals, and sometimes nothing but lichens. It is important, however, to observe that this barren sand has been made to bear good corn-crops, and been totally reclaimed by the action of chalk when applied in large quantity. Anthony Bacon, Esq. of Benham, near Newbury, Messrs. Batten and Bridgeman of Highclere, and others, upon land of this description rented of Earl Carnarvon, have applied chalk with most extraordinary success; and I have seen land which was almost utterly unproductive of food for man or beast, and seemed destined to irreclaimable barrenness, after being broken up and heavily chalked, become loaded with fine crops of wheat and turnips, &c.

"Mr. Bacon tried the effect of dung without calcareous matter most fully, and without success; the manure only producing a more luxuriant growth of a small Arenaria that strangled the corn

The irregularity of structure, which I have to describe on the west of Kingsclere, consists in a sudden and unusual elevation of the chalk, accompanied by fracture and an inverted dip, which will be best understood by referring to the annexed section and map. (Pl. XVII.) At Inkpen Hill the chalk rises to the height of 1011 feet, the greatest elevation which it attains in England: it here also forms the highest point of a double series of strata, which from thence to Highclere Park are seen to dip, on either side of a central axis, in two opposite directions, nearly north and south; the axis itself or anticlinal line running nearly from west-north-west to east-south-east, parallel to the edge of the basin of Newbury and to the high ridge of chalk. This opposite dip, from Inkpen to Highclere, is seen in the chalk-pits that are met with along the intermediate valleys; but from Highclere Park to Kingsclere, it is more distinctly marked by the bursting up of beds of the upper green-sand or firestone from beneath and between two opposite escarpments of chalk. The northernmost of these escarpments dips rapidly to the north, beneath the plastic clay formation of the basin of Newbury; the southernmost dips less rapidly to the south, *i. e.* towards the basin of Hampshire. The general elevation of this southern escarpment is nearly twice as great as that of the northern, and its dip is less in nearly the same proportion. To it belong the summits of Beacon Hill and Ladel Hill, which form landmarks to all the surrounding country, and are sometimes called the Burghclere Hills. At the eastern extremity of this tract of green-sand, the two chalk-escarpments close round and become confluent, with a dip and bearing conformable to those of the subjacent sandstone. The valley comprehended within these escarpments is from 4 to 5 miles long, and from 1 to 2 miles broad. I shall call it the Valley of Kingsclere, from the small town situated at its eastern extremity.

On the slope of the southern escarpment, between Beacon Hill and Ladel Hill, a considerable thickness of hard and gray chalk or chalk-marl is seen to divide the softer chalk of the summit from the green-sand or firestone which forms the base; but on the northern escarpment the total superficial breadth of the chalk, owing to its more rapid dip, is comparatively small.

The green-sand (or firestone) of the vale of Kingsclere, in substance and organic remains, resembles that of Merstham and the vale of Pewsey, and the upper green-sand of the Isle of Wight. It contains irregular and subor-

---

and remained in triumphant occupation of the soil; whilst in the other half of the field, on which he had laid the chalk in the same year, he had a magnificent crop of corn and no Arenaria whatever; this plant, as well as sorrel and other weeds, disappearing where the chalk had been laid."

dinate beds of chert; its greatest elevation is nearly the same as that of the northern chalk-escarpment, neither the one nor the other being high enough to interrupt the view of the southern escarpment, which is seen from all parts of the vale of Newbury; as will be better understood by referring to the section, than from verbal description.

This unusual position of a valley, composed of green-sand, within the apparent area of a chalk-basin, derives illustration from some other similar instances which I shall mention, of valleys produced by the disturbance and removal of the superior strata, and which occur as we follow the edges of the chalk, south-westward from Kingsclere, through Wilts and Dorset towards Weymouth. These all present the same features of a valley, circumscribed on all sides by an escarpment, whose component strata dip outwards in all directions from an anticlinal line, running along the central axis of the valley. The first of them occurs near the villages of Ham and Shalbourne, about 5 miles to the west of the valley of Kingsclere, and differs from it only in the circumstance of the escarpment, which is continuous on every side but the south, being less elevated, and the area within being less extensive. The western end of this valley is separated from the upper extremity of the vale of Pewsey by only a narrow and low bar of chalk, stretching like a bridge across the green-sand. Without this bar, the valley of Shalbourne would have been confluent with the upper end of the vale of Pewsey.

Another valley of the same kind occurs at Bower Chalk, about 10 miles to the east of Shaftsbury. In this case also the strata consist of chalk resting upon green-sand: the inclosing bar or isthmus of chalk is known by the name of Cleve Hill, and without it the valley of Bower Chalk would have been confluent with that of Alvedeston, which expands into the plain of Shaftsbury.

A third and still more striking example may be seen at Poxwell near Osmington, about 7 miles on the north-east of Weymouth, being nearly elliptical in shape, and in size not much exceeding two or three times that of the Coliseum at Rome. In the circumstances of the strata dipping in every direction from a central axis, and of the valley being inclosed by a circumscribing escarpment, it perfectly coincides with the four valleys in chalk and green-sand above enumerated, and differs only in the fact of the strata inclosing it consisting of Portland stone and Purbeck marble.

The drainage of these valleys is generally effected by an aperture in one of their lateral escarpments, and not at either extremity of their longer axis, as would have happened had they been simply excavated by the sweeping force of rapid water; and as it is utterly impossible to explain the origin of any valleys of this description by denudation or alone, indeed without referring the present

position of their component strata to a force acting from below, and elevating the strata along their central line of fracture, I shall venture so far to involve this theory of their origin with the facts which they display, as to designate them by the appellation of *Valleys* of ELEVATION: of course due allowance must be made for their subsequent modification by diluvial denudation. For further examples of inclosed valleys, affording similar axes or centres of elevation, I refer to the map and section of the Bristol coal-basin, accompanying the memoir by Mr. Conybeare and myself on the S.W. coal district of England, in the last volume of the Geological Transactions, [Vol. i. Part II. 2d series;] where, in following the anticlinal lines that traverse that district, it will be seen that the strata on either side of them are in some places elevated into lofty ridges, and in others pass along the lowest points of the valleys. An example of the latter kind may be seen in the Vale of Westbury near Bristol; and also near Thornbury, Berkeley, and Newnham on Severn. In the section of the South-Welch mineral basin, (Pl. XXXIV. of the same volume,) a similar example occurs in the Vale of the Ely to the west of Llandaff; and in following the great anticlinal line which extends across the Severn from the west extremity of the Mendip Hills through Glamorganshire and Pembrokeshire to Milford Haven, there are several examples of valleys similarly constructed, and composed of a basis of old red-sandstone, inclosed by hills of limestone, which face each other with an opposite escarpment, and have an opposite dip.

It will be seen, if we follow on Mr. Greenough's map the south-western escarpment of the chalk in the counties of Wilts and Dorset, that, at no great distance from these small elliptical valleys of elevation, there occur several longer and larger valleys, forming deep notches, as it were, in the lofty edge of the chalk. These are of similar structure to the smaller valleys we have been considering, and consist of green-sand, inclosed by chalk at one extremity, and flanked by two escarpments of the same, facing each other with an opposite dip; but they differ in the circumstance of their other and broader extremity being without any such inclosure, and gradually widening till it is lost in the expanse of the adjacent country.

The cases I now allude to, are the Vale of Pewsey to the east of Devizes, that of the Wily to the east of Warminster, and the valley of the Nadder extending from Shaftsbury to Barford near Salisbury; in which last, not only the strata of green-sand are brought to the surface, but also the still lower formations of Purbeck and Portland beds and of Kimmeridge clay.

It might at first sight appear that these valleys are nothing more than simple valleys of denudation; but the fact of the strata composing their escarpments

having an opposite and outward dip from the axis of the valley, and this, often at a high angle, as near Fonthill and Barford in the vale of the Nadder, and at Oare near the base of Martinsell Hill in the Vale of Pewsey, obliges us to refer their inclination to some antecedent violence, analogous to that to which I have attributed the position of the strata in the inclosed valleys near Kingsclere, Ham, and Burbage. Nor is it probable that without some pre-existing fracture or opening in the lofty line of the great chalk-escarpment, which is here presented to the north-west, the power of water alone would have forced open three such deep valleys as those in question, without causing them to maintain a more equable breadth, instead of narrowing till they end in a point in the body of the chalk.

A still larger and more decided example of the same kind of valley of elevation occurs in the well-known case of the great valley of the Weald of Kent and Sussex; surrounded as it is on all sides but the east by lofty escarpments of chalk, facing towards each other with an outward dip in every direction, and traversed from east to west by a central anticlinal line; on either side of which line the strata of iron-sand, weald-clay, lower green-sand, gault-clay, and firestone sink like the two sides of a roof, with a high and regular inclination beneath the inclosing escarpments of the chalk of the North- and South-downs. The structure of this valley has been well represented in the sections of Kent and Sussex published by Mr. W. Smith, and also in the section that accompanies the inestimable work of Messrs. Conybeare and Phillips on the Geology of England. This district has been usually described by the name of the Kentish Denudation, seemingly from the hypothesis that the exposure of all the strata here laid open, beneath the chalk, was the effect simply of denudation. Now I am disposed fully to allow, that the force of water has been sufficient to sweep away the greatest portion of the loose and shattered fragments, which, after the elevation I am assuming, must have covered the axis of this as well as the other valleys we have been considering, and which must still have remained there in the form of rubbish, had there been no subsequent diluvial action to drift them away: but I think the slightest inspection of the sections I have referred to, will at once convince us, that no power of denudation by water could have produced the doubly inclined position of the entire body of the strata within this district, as well as of the chalk by which it is surrounded; and that we must here again have recourse to a force producing elevation from beneath, along the axis of the valley, if we would find an adequate cause for the effects that have been produced in it along an extent of 60 miles in length and 20 miles in breadth.

The facts then which we have examined, conspire to lead us to the conclu-

sion, that not only many inclosed valleys similar to that of Kingsclere, but also, in a less degree, many open valleys similar to that of Pewsey and the great central valley of Kent and Sussex, though largely modified by denudation, owe their origin to an antecedent elevation and fracture of their component strata; and these phænomena may be regarded as of frequent occurrence in the formations of all ages, and as indicating the multitude of disturbing causes by which the earth's surface has been affected.

Another question of some moment derives much light from the evidence afforded by the valley of Kingsclere and the contiguous district along the line of junction of the plastic clay with the subjacent chalk, *viz.* whether the chalk was disposed in its present form of troughs or basins before the deposition of the tertiary formations now inclosed in them? or (to speak more locally) whether the basins of London and Hants existed in their present relative position to each other and to the chalk, before the epoch of such deposition? and I think the evidence we here find, shows as decisively for the basin of London, as that which we collect at the two extremities of the Isle of Wight and near Corfe Castle does for the basin of Hants and Dorset, that the present inward inclination of the southern edges of both these basins has taken place since the deposition of the Plastic, and also, probably, of the London, clay.

The sections near London afford us no means of judging of this question, as all the tertiary strata are here nearly horizontal and parallel to those of the horizontal chalk. But where it happens (as it does near Highclere) that thin and regular beds of sand, gravel and clay, are disposed at a high angle, and exactly parallel to the strata of the subjacent chalk, along a considerable tract of country, it is no less certain that the movement of both these formations, whether by elevation or depression, was contemporaneous, than it is clear from the section at Alum Bay, that in the Isle of Wight the vertical and parallel position of the same formations on the south frontier of the Hampshire basin was posterior, not only to the deposition of the plastic, but also of the London, clay.

Assuming then, that the London and Hampshire basins did not hold their present relations to each other and to the intermediate elevated plains, at the time of the deposition of the plastic clay, the next inquiry is, whether on these plains there be any evidence to show that the tertiary strata which now repose almost exclusively within these basins, have been originally more continuous than they are at present, or perhaps united together.

Now it happens that the space dividing the basin of London from that of Hampshire is almost wholly occupied by an elevated plain of chalk, the average level of which exceeds that of the tertiary hills within the area of

these basins, whilst its surface is diversified by undulations of valleys and hills, the latter varying from 600 to 1000 feet above the level of the sea.

Had the tertiary strata of our two basins been ever united together in one, it were to be expected that some traces of such union would remain in the space that now divides them; and such traces we actually find on those portions of this district that constitute even the highest summits of the chalk-formation that exist in England, *viz.* on the top of Combe Hill, a little east of Inkpen Hill near Highclere; on Chidbury Hill and Beacon Hill, that form two of the highest summits of Salisbury Plain between Amesbury and Everleigh; on the top of Clay-pit Hill on Chiltern Down, near Heytesbury; and at still more distant points, on the lofty summits of Blackdown Hill between Dorchester and Abbotsbury in Dorset, and of Nettlebed and Stokenchurch in Oxfordshire.

At all these elevated points, the identity of character which the strata on these detached hills and ridges uniformly possess with that of the plastic clay formation in the basins of London and the New Forest, affords abundant ground for concluding that these two basins were originally united together in one continuous deposit across the now intervening chalk of Salisbury Plain in Wilts, and the plains of Andover and Basingstoke in Hants, and that the greater integrity in which the tertiary strata are preserved within the basins, has resulted from the protection which their comparatively low position has afforded them from the ravages of diluvial denudation.

The tender and destructible nature of the sand, clay and gravel composing this formation, would render them peculiarly liable to be swept away by the transit of violent currents of water; and the wreck of the harder portions of sandy strata thus destroyed, is sufficiently evident in the enormous blocks of sandstone which not only occur in Wilts, in numbers so great as to lie like a flock of sheep in the valleys near Hungerford, and thence derive the local name of *gray wethers,* but are in more or less abundance co-extensive with the entire surface of the chalk, from the Wolds of Yorkshire to the Hills of Sidmouth and Blackdown in Devonshire.

Their abundance at Clatford Bottom near Marlborough, between the Druidical temples of Abury and Stonehenge, whose materials they have supplied, is mentioned in my "Reliquiæ Diluvianæ." Windsor Castle is built of a similar stone, found in insulated blocks on Bagshot Heath. Another example of their occurrence in vast numbers on the naked surface of the chalk, at Ashdown Park on the south of Swindon, has been described by Dr. Kidd. A similar case occurs on the slope and summit of the chalk hill which overhangs the village of Portisham near Abbotsbury in Dorset: blocks of the same kind abound also near Sidmouth. In all these cases many of the blocks still remain

at the highest levels on the summits of the hills, whilst others have been drifted to the adjacent valleys, and sometimes, as at Portisham and Sidmouth, beyond the present area of the chalk*.

The general dispersion of these enormous blocks, which probably once existed as concretions in extensive beds of sand, since swept away in consequence of their buoyancy, affords strong evidence, in addition to that supplied by the residuary patches and outliers of plastic clay, that these tertiary formations were once deposited over nearly the whole surface of the chalk in the south of England; and that their separation into the two distinct basins of London and Hampshire has resulted, partly from local elevations and depressions by subterraneous violence, since the deposition of the plastic clay; and partly from the still more recent removal of much of their substance by diluvial denudation.

I cannot leave this subject without referring to the remarkable fact of the occurrence of insulated portions of tertiary strata, as well as of chalk and greensand, on the summits of the Savoy Alps, at elevations of more than 10,000 feet above the level of the sea; which seem to bear the same relation to the tertiary strata of the valleys of Italy, France, and Germany, that our trifling Heights of Inkpen in Hants, Blackdown in Dorset, and the North Downs in Surrey, bear to the lower regions of the Basins of London and Hants. As these Alpine deposits are contemporaneous fragments of the more extensive strata of the adjacent low countries, we are forced, in explaining their present position, to adopt one or other of two conclusions; either, that at the time of the deposition of these strata the sea covered, not only the highest portions of the chalk of England, but also the summits of the Savoy Alps; or, that since the deposition of these beds, by elevation of the mountains or depression of the valleys, or by the united effect of both these causes, the relative level of the one to the other has been changed to an amount of many thousand feet. Now as the undisturbed and nearly horizontal position in which the tender and frangible materials of the tertiary strata still remain in the basins of Paris and Lombardy forbids us to suppose that any depression could have brought them down so quietly to their present level, the theory of the elevation of those few portions which occupy the Alpine summits, remains by far the most probable that is submitted to our choice.

The idea first suggested from the examination of the basins of Paris and

* These blocks at Sidmouth afford a beautiful example of a siliceous breccia of the same age and character with the well known Hertfordshire pudding-stone; and agreeing with some varieties of it in the circumstance of the chalk flints remaining angular, and not being rolled to pebbles, as more frequently is the case.

Lombardy, that the tertiary strata were limited in their extent to certain hollow spaces within the area of the chalk, has been proved incorrect by the discovery of similar strata very extensively over Europe; and an excellent account of these further discoveries has been recently given by M. Brongniart in the 2d edition of his History of the Environs of Paris.

They have also been found to occur in the most distant regions of Asia, Africa, and America; so that these deposits, which were at first considered simply local, are proved to be among the most extensive, as well as the most recent, that have taken place on the globe: and as their general position is certainly, for the most part, in the lowest spaces of the earth's surface, and their existence in mountain-summits but an occasional and rare anomaly, the most simple solution of their appearance in such lofty situations will be found in the hypothesis, that these mountains have been elevated since the period at which the position of the tertiary strata took place.

I shall now add a few remarks on the diluvian and post-diluvian deposits that occur within this district.

The diluvian deposits do not differ materially from the ordinary gravel of the London basin. The thickness and extent of these beds of gravel are very irregular. They consist chiefly of chalk-flints, more or less rolled; a few rounded pebbles of the Lickie sandstone, and occasional fragments and blocks of the tertiary gray-wether sandstone, being intermixed. Near Newbury they have been occasionally found to contain the remains of the elephant, rhinoceros, ox, stag, horse, &c.

The post-diluvian formations are limited to the flat meadow district which forms the valley on each side of the Kennet, from Hungerford nearly to Reading; and consist, 1st of peat, and 2dly of marl (here called *malm*), analogous to the shell-marl which accompanies the peat of many shallow lakes in Scotland and England. The average width of the peat is less than a mile, and its thickness varies from 5 to nearly 15 feet. Large quantities of it are dug for fuel, and are also burnt into peat-ashes, which serve as a top-dressing for land. It is much intermixed with minute crystals of selenite and a small quantity of carbonate of lime, and abounds with branches and other remains of trees, *viz.* fir cones, nuts and seeds; and also with the bones and horns of oxen, red deer, roebucks, horses, wild boars, and beavers. A human skull of high antiquity has also been found in it at a depth of many feet, at the contact of the peat with a substratum of shell-marl*. It was accompanied by rude instruments of stone,

* This skull, together with a valuable collection of horns, teeth, and bones from the peat bogs near Newbury, has, by the kindness of Colonel Page and J. Hempstead, Esq. of Newbury, been presented to the Oxford Museum.

which lead us to conclude that it was the skull of one of the aboriginal inhabitants of the island, who had not the art of working metals. Along the northern edge of this peat bog there is a considerable deposit of marl mixed with calcareous tufa, known to the natives on the west of Newbury by the name of the *strand*; a name evidently derived from the circumstance of its forming a kind of wide calcareous causeway along the edge of the moor, rising like an artificial terrace a few inches above the present level of the adjacent meadows. It is often 60 feet and more in width, and varies from 2 to 10 feet in thickness, and is frequently interstratified with beds of peat varying from 6 inches to 3 or 4 feet in thickness: its substance is, in some parts, a soft laminated cream-coloured marl; in others it is tufaceous and granular, and the grains (which are usually rugged and of the size of a small pea) are often conglomerated into spherical and lenticular balls, varying in diameter from 1 inch to 2 feet. Many of these balls are formed of concentric layers concreted around some extraneous body as a nucleus: occasionally, we find them elongated to a cylindrical form, and containing a central cavity, in which there is either a branch of wood or traces of the decayed remains of a branch.

Other concretions are formed round the bones or horns of animals that appear to have been stranded on this terrace, whilst it was accumulating; and throughout the substance of the marl, as well as of the tufaceous beds, are dispersed the same varieties of horns and bones that occur in the peat, and multitudes of shells of the same freshwater Molluscæ which now inhabit the adjacent river. These freshwater shells are in various stages of decay; and from this circumstance, I am disposed to refer the origin of the calcareous matter of the strand to the detritus of dead shells that have in former times been accumulated along the boundary-line of the highest floods of the river,—an opinion which derives support from the fact of this strand being almost exclusively limited to the north frontier of the valley; *i. e.* to that side of it, which in the seasons of flood would be the repository of all drifted materials, wafted by the prevailing winds of this country (namely the S. and S.W.) to the lee-shore.

The skimmings of these flood-waters would be composed nearly of dead shells; and if we suppose all but the most recent of them to have undergone decomposition during the period of their lying in the strand, and their calcareous materials to have been converted into the marl and tufaceous concretions of which this strand is composed, we adopt an hypothesis fully adequate to explain the phænomena. The slight traces of shell-marl which occur in a bank parallel to the strand and nearly in the middle of Benham Marsh, and in a few islands that rise occasionally in the main body of the peat, are to be ex-

plained on the same theory; and all these facts, as well as their explanation, are, I believe, in perfect harmony with those of the peat-bogs in the meadows adjacent to the river Test near Romsey, which have been laid before the Society by our Secretary, Mr. Lyell.

It is quite impossible to refer the origin of the tufaceous portion of these marl-beds to the action of springs or of flood-waters, charged with carbonate of lime; since there are no springs that pour their waters along the line of the deposits in question; and, if we would refer them to a precipitation of calcareous matter from the flood-waters of the Kennet, we should expect similar deposits along all the frontier-lines of these floods, and they would not be limited to the lee side of the valley, and to insular projections in the body of the marsh.

The total amount of similar driftings along the south border of these bogs is so trifling as to be rarely visible, and is no where known to exceed a foot in thickness.

The best opportunity of examining the structure of the marl-beds that compose this strand, is afforded in the extensive sections, now open at Benham Marsh, about 3 miles west of Newbury. The marl is also visible in a less perfect degree in the turbaries close to the London road at Woolhampton, about 7 miles on the east of Newbury.

XII.—*Notices and Extracts from the Minute-Book of the Geological Society.*

1.—*On the Iron-Sand Formation of Sussex.* *By* Gideon Mantell, Esq. F.R., L., and G. S.S. *In a Letter to Dr.* Fitton, *Secretary of the Geological Society.* [Read June 14th, 1822.]

Sir,

A SHORT time since I had the honour of presenting to the Society a series of specimens, illustrative of the physical characters and organic remains of the strata of Tilgate Forest. I now submit to its notice some additional examples of the fossils of those deposits, and beg to offer some further observations on their geological position and relations.

In my work on the Geology of Sussex, I have mentioned the difficulties which attended the determination of their geognostic position, and the reasons which led me to consider them as related to the Purbeck limestone; but a more accurate survey of the district in which they occur, made in company with my friend Charles Lyell, Esq., Sec. G.S., &c. has enabled me to ascertain that such an opinion is not tenable, and that these strata may with greater propriety be associated with the subordinate beds of limestone, sandstone, and clay, which, in certain parts of Sussex, alternate in the iron-sand formation.

In the present state of our knowledge, it may be convenient to separate the strata under consideration into two divisions; comprising in the first the Ashburnham limestone, and in the second, the strata of Tilgate Forest, as in the following tabular arrangement.

	Subdivisions.	*Organic Remains.*	*Localities.*
1. Ashburnham beds.	Beds of argillaceous limestone and shale. . .	Immense quantities of bivalve shells	Ashburnham, near Battle; Euson's Green, near the Black-boys.
2. Strata of Tilgate Forest.	Beds of sandstone and clay	Bones of birds, turtles, saurian animals, fishes; teeth of crocodiles, and unknown animals of the lizard tribe; ferns, fruits, and vegetables, allied to the Cycas and Euphorbium; univalve and bivalve shells	Hastings, Chailey, Lindfield, Cuckfield, Tilgate and St. Leonards Forests; Horsham, &c.

The strata of the first division (the Ashburnham limestone) have been so fully described in my work, entitled Illustrations of the Geology of Sussex, that it is unnecessary in this brief notice to do more than refer to the account alluded to. These beds underlie the strata of Tilgate Forest, and perhaps may hereafter be ranked with the Purbeck limestone, which in some respects they resemble. The sandstone, &c. of Tilgate Forest are so well characterized by their remarkable fossils, that their existence in remote localities is easily determined. In every quarry where these beds are exposed, their organic remains have been discovered more or less frequently.

Mr. Webster, in 1813*, noticed beds of sandstone with intervening layers of clay and sand, in the cliffs at Hastings, and discovered in them the bones, teeth, and other remains of animals and numerous vegetables. The vegetables allied to the Cycas, so commonly found at Tilgate Forest, are also of frequent occurrence in the sandstone of Hastings; large rolled portions of them are constantly seen on the shore, which have been washed out of the cliffs and thrown up by the waves. At Rye and Winchelsea, strata of a similar character have been observed by Mr. Lyell, who informs me, "that the rock on which the latter town is situated, rising from beneath the alluvial marsh by which it is surrounded, presents cliffs more or less abrupt towards every point of the compass. In a quarry on the road-side, near the ancient gateway leading to Rye, the strata are distinctly exposed. The summit and base of the pit consist of sand with layers of friable sandstone; and in the centre a stratum of limestone occurs 5 feet thick. In the cliffs, considerably below the level of the base of the quarry, another bed of limestone is seen imbedded in the iron-sand, thus clearly proving the alternation of these deposits. The flat slabs of the limestone of Winchelsea, where weather-worn, exhibit casts of small bivalves, which also appear in the intervening layers of sandstone. Rye, like Winchelsea, is built upon a hillock of the iron-sand formation, containing beds of calciferous sandstone."

In tracing the Tilgate strata in their course westward, in the direction of a line drawn from Hastings to Framfield, and from thence to Horsham, we find them exposed in several quarries, which have been opened for repairing the roads and other economical purposes; but the surface exposed is too inconsiderable to afford any decisive information respecting their geological position. Chailey, Linfield, Cuckfield, St. Leonards and Tilgate Forests, may be mentioned as the most interesting localities.

Still further to the west the strata are exposed to a considerable extent in

* See Sir H. Englefield on the Isle of Wight, p. 237.

the vicinity of Horsham. Mr. Lyell has favoured me with the following section and description of a quarry at Stammerham, near that town.

"*Section of Stammerham Quarry, near Horsham.*

	Provincial Terms.	*Thickness.*
1. Vegetable mould		1 foot 6 inches.
2. Stiff clay and loam		9 feet.
3. Compact calciferous sandstone, with deep undulating furrows on the upper surface	Rough Causeway	4 inches.
4 & 5. The same rock, but more indurated, in two layers; the upper four inches, the lower one twelve inches thick: (an excellent road material)	Scrub Stone	1 foot 4 inches.
6. Ferruginous sandstone (pulverized for bricks)		1 foot.
7. A blue soapy marl		1½ foot.
8. Ferruginous sandstone, like No. 6.		1 foot.
9. Hard calcareous sandstone, used for roads and rough paving	Ground Pinning-stone.	1 foot.
10. Compact calciferous sandstone, of finer texture than any of the above. It occurs in large slabs, and forms an excellent paving material for kitchens, &c. It is slightly marked with undulating furrows on the upper surface		2 feet.
11. Marl sunk through, but not worked		4 feet.
12. Stone in slabs, reached by boring		depth unknown.

"In the calciferous sandstone, No. 10, according to the report of the workmen, the bone of an animal was discovered some years since: organic remains, however, appear to be rare. No shells occur; but branches of vegetables in a carbonized state are often met with. The quarry at Tower Hill, near Stammerham, so nearly resembles the latter, that it is unnecessary to describe it. Near this an incrusting spring rises, which covers the vegetables in the ditches through which it flows, with calcareous tufa.

In the quarries at Sedgwick, 2 miles from Stammerham, Mr. Lyell observed a large quantity of slabs of paving-stone, many of which were deeply furrowed on both sides. This appearance is common in the sandstone throughout Sussex, and appears to have been formed by the advance and retrocession of the waves.

The dip of the strata near Horsham is very variable: in some instances it

takes place in every direction; in others, the beds are nearly horizontal, and are worked over a considerable area without descending deeper."

Mr. Lyell remarks in the same letter, "that upon examining the collection of the Geological Society, he has found, among the specimens from Battle, one which agrees with the calciferous sandstone of Tilgate Forest, and contains carbonized wood: and that among a series of specimens from the cliffs at Hastings, collected by Mr. Webster, which still more closely correspond with those of Tilgate Forest, there are the teeth of fishes and amphibia, and the rib of an animal, inclosed in the rock."

From the preceding observations we may, I think, fairly conclude, that the calciferous sandstone of Rye, Winchelsea, Hastings, Tilgate Forest, and Horsham, are but different portions of the same series of deposits, belonging to the iron-sand formation; the Ashburnham beds being situated beneath them.

The organic remains which I have now the honour to present to the Society, may be considered as characteristic of the strata of Tilgate Forest. They are as follow:

Stems of vegetables allied to the genus Cycas*, and, perhaps, Euphorbium.
Leaves of a species of fern
Plates and bones of turtles.
Teeth and bones of crocodiles and other saurian animals, of an enormous magnitude.
Bones of birds.
Teeth and scales of fishes.
Teeth of an unknown herbivorous reptile, differing from any hitherto discovered either in a recent or fossil state.
Teeth of an animal of the lacertian tribe, resembling those found at Stonesfield near Oxford, and figured by Lhwyd.

I have the honour to be,

Sir, &c.

Castle Place, Lewes, June 1, 1822. GIDEON MANTELL.

* Some of these closely resemble the stem of *Cycas revoluta*. Of this plant, a fine recent specimen may be seen in the magnificent collection of palms of Messrs. Loddiges at Hackney.

2.—*Section of a Well sunk at Streatham Common, in the County of Surrey. By* Mr. Thomas Yeats: *in a Letter addressed to* —— Brown Esq., *Secretary to the Westminster Fire-Office; and by him communicated to the Geological Society.* [Read April 2d, 1824.]

Sir, Streatham, December 19, 1823.

Having had the superintendence of sinking a well on Streatham Common to the depth of 100 feet, and of boring from the bottom of the well to the further depth of 185 feet, I herewith send you specimens of the various strata found in the progress of the work. The total depth of 285 feet is the greatest which has hitherto been pierced in this part of the country.

The London clay is here of considerable thickness, commencing almost immediately beneath the vegetable mould, and continuing to the depth of 180 feet, when it becomes strongly mixed with sand. The specimen of clay from the depth of 200 feet contains many fragments of shell, which have been broken exceedingly small by the auger. Of this clay I immersed considerable quantities in water, in the hope of finding a perfect shell; but without success. From what I have observed in the present sinking, as well as in other parts adjoining, this appears to me to be a stratum, nearly 30 feet thick, consisting principally of oyster-shells.

At the depth of 235 feet we pierced the spring, which has hitherto supplied this place with *hard* water. Up to this point we experienced no difficulties, but such as arose occasionally from hard substances, which we passed through by using the punch instead of the auger. The stratum of variegated clay, at the depth of 256 feet, was very troublesome; since after drawing the rods for the purpose of emptying the auger, it swelled again into the hole before they could be lowered. The hard rock, at the depth of 265 feet, caused great delay, the punch having been used three days before it could be perforated.

In the course of this work very few shells were found: in fact, the small quantity of earth brought up by the auger gave me no room to hope for many.

I am, Sir,

Yours respectfully,

Thomas Yeats.

Specimens which accompanied the preceding Letter.

		At the depth of
Vegetable Mould	from 0 to 2 feet.	
London Clay	Reddish-brown clay	2 to 34
	Septarium	35
	Bivalve shells and pyritous wood, with Teredines	70 to 90
	Blue clay, somewhat sandy	180
Plastic Clay Formation	Blue clay and broken shells, about 30 feet thick	200
	Sandy blue clay	205
	Ash-coloured sandy clay	210
	Ash-coloured, yellow, and blue clay	215
	Blackish clay, with coaly matter	220
	Rounded flint pebbles	230
	Ash-coloured sand, above the hard-water spring	235
	Mottled plastic clay	240
	Do. with soft chalky particles intermixed	242
	Do.	246
	Red, green, and yellow mottled plastic clay	256
	Green sand, with rounded carious flint pebbles	260
	A mixture of iron-pyrites and sand, very hard	265
	Green sand	270, 274, 278
	Light-coloured sand, immediately above the spring of soft water	280

3.—*Notice respecting the Quartz-rock of Bromsgrove Lickie.* *By* Mr. James Yates, F.G.S. [Read June 7th and 21st, 1822.]

The notice here offered to the consideration of the Society relates to the quartz-rock of Bromsgrove Lickie, described by Professor Buckland in the 2d part of the 5th volume of the Geological Transactions. A reference to the accompanying specimens will best explain the facts which I wish to mention.

No. 1. exhibits the usual appearance of the rock. It is a granular quartz, in which are imbedded rounded grains of quartz and of decomposing white felspar, with particles of black oxide of iron. This rock passes, on the one hand, into a coarse friable sandstone, in which the crystalline structure entirely disappears; and on the other, into a rock composed of minute quartz-crystals.

Nos. 2, 3, 4. show the gradation into sandstone, in which the particles of sand are held loosely together by ferruginous clay.

Nos. 5, 6, 7, 8. show the opposite gradation into a rock, also friable, containing in small quantity a cement of clay, but consisting almost wholly of minute quartz-crystals, not half a line in length, with brilliant faces and sharp angles, having the form of six-sided prisms terminated at each end by six-sided pyramids, and with the striæ on the sides distinctly perceptible by the aid of a microscope. A circumstance still more remarkable in this variety of the rock is, that it contains impressions of shells. I observed this appearance in two different places: in both instances it was among the uppermost strata of the formation. No. 5. is from the western side of Rubery Hill, which belongs to the series of hills called by Mr. Buckland "the Lower Lickie Range." Nos. 6, 7, 8. are from the eastern side near Colmore's Farm, where a shaft has been dug to the depth of 40 or 50 yards in search of coal. Some of the usual beds belonging to the coal strata, such as *clunch* and *peldon*, were found in sinking this shaft. At a considerable depth there occurred a stratum of shell-limestone, of which No. 9. is a specimen. On sinking into the quartz-rock, the water rose so rapidly that the work was abandoned. This quartz-rock contains no trace of lime, and I have not seen any remains of the shells, but only the impressions, showing them to have been of the same kind with some of those in the superincumbent limestone. These shells appear to belong to the genus Anomia.

Mr. Buckland states, that it has been questioned, whether the quartz-rock before us is a primitive, or a transition rock. The impressions of shells may assist in settling this question, and in ascertaining the relation of the interesting rock, in which they occur, to the other English strata.

Besides the narrow defile through which the Birmingham road passes, when the rock dips to the south-west, I examined the rock at 5 or 6 other places, and found it sometimes dipping at a high angle in an opposite direction, and sometimes nearly horizontal.

4.—*Notice respecting the Pebbles in the Bed of Clay which covers the New Red Sandstones in the S.W. of Lancashire. By* Dr. Bostock. [Read March 31st, and June 6th, 1823.]

The extensive deposit of new red sandstone, which occupies nearly the whole of the county of Chester and a part of that of Lancaster, at the S.W. angle of the latter county is for the most part covered by a mass of sandy clay. The colour of the clay is nearly that of the rock on which it rests; its different parts differ considerably in the proportion of its siliceous to its argillaceous matter; but although it is usually denominated a marl, and is employed in the neighbourhood for the improvement of the soil, it contains but a very small quantity of calcareous matter, and in many parts is entirely without it. It abounds in rounded pebbles of all sizes, from the most minute to masses of 3 feet or more in diameter, which are deposited through every part of it. The pebbles may be considered as about equally numerous in the upper and lower portions of the clay, and deposited in it without any kind of arrangement; but upon viewing an extensive section, certain parts are found to contain a greater number than others; in general the most argillaceous parts contain the fewest pebbles. The thickness of the clay partly depends upon the inclination of the upper surface of the rock on which it rests. On the N.E. bank of the Mersey, about 3 miles above Liverpool, the clay in some parts presents a face of 30 or 40 feet in height, while those parts of the red sandstone which are in any considerable degree elevated above the ordinary level of the district, rise above the clay. Its upper surface is, however, far from being horizontal, although more nearly so than that of the rock. In some parts, where fissures in the sandstone have produced narrow valleys, or, as they are termed, *dingles*, the clay appears to be wanting; while, on the contrary, there are some knolls above the average level which are covered by it.

The upper portion of the bed of clay, for about 10 inches in depth, is obviously of a somewhat different nature from the great mass of it, being more sandy and of a lighter colour, and containing a great number of very small pebbles, although seldom any of the large ones. This upper stratum differs

very materially from the rest of the mass in its agricultural character, being decidedly unfavourable to vegetation; it has obtained the provincial appellation of *ravin*. I have had frequent opportunities of verifying the accuracy of the remark, both from direct experiments, and from observations on the growth of plants, the roots of which had penetrated into this substance. The immediate cause of its injurious effects would appear, in part at least, to depend upon the tendency which it has to become indurated in dry and warm weather: under such circumstances it has been rendered so hard as to be incapable of being penetrated by a spade.

The existence of this upper stratum would seem to indicate, either that the whole of the clay was originally deposited in the way in which it now lies with respect to its upper surface, or that, after the great body of the clay had been deposited, and had experienced the action of various causes upon its surface, the "ravin" was deposited by a subsequent and independent operation.

The specimens now laid before the Society, were taken from the clay-bank mentioned above, and may afford an idea of the nature and variety of the rocks of which the pebbles are composed. It would not be easy to state the proportion which the pebbles bear to the clay in which they are imbedded; but they are so numerous, that, in the more sandy parts, a square yard of the clay would yield some dozens of them of sufficient size to be easily collected. In all cases, or at least with a very few exceptions, they exhibit marks of having undergone a great degree of attrition, their edges and angles being very much worn down. With respect to the proportion in which the different kinds of pebbles exist, perhaps the most frequent are clay-slate, greenstone, and basalt; the granitic are not uncommon, and some of the largest masses consist of this rock: quartz pebbles are also not unfrequent, but generally of small size. No decided organic remains have been observed in this clay; for although vegetable matter, and even what appears to be roots of plants, is occasionally found in it, these may have belonged to trees that have grown in the clay after it was deposited in its present situation. It is worthy of remark, that when the clay is exposed to the atmosphere, it frequently becomes clothed with a plentiful crop of the *Tussilago Forfara;* and this has been observed to be the case with portions of it that have been originally many feet below the surface of the earth.

5.—*Extract of a Letter from* Alexander Gordon, Esq. *to* D. Gordon, Esq., *of Abergeldie, describing three successive Forests of Fir embedded in a Peat Moss;—accompanied by Specimens.*

It having been reported to me that the remains of distinct forests of fir timber, as large as any now growing in Brăemār, were to be found in your moss of Auldguissack, I went yesterday to inspect it.

The moss from the lower part of the hill to the Muick or river, varies in depth from 18 inches to 10 feet and upwards, presenting an inclined plane in some places of rather uneven surface, and gradually elevated from the Muick to the bottom of the hill.

On digging into the moss in two different places, we discovered large roots of Scotch fir-trees, about one foot below the ordinary average level of the moss. Under the bottoms of these roots there was a stratum of about a foot and a half of moss, below which other roots or trunks of trees appeared; and on digging still further down (about 6 or 7 feet below the ordinary level of the moss), a third set of roots and truncated stems of trees were discovered; this lowermost set presenting the appearance of having been destroyed by fire, as the charcoal was quite distinct on them. It seemed impossible that these three series of roots could have supported different trees all growing *at the same time*, for the ramifications of each (horizontally, like Scotch firs at the present day,) are quite distinctly bedded in moss, and placed perpendicularly above each other. It is therefore clear, that these are the remains of three different forests of wood, which had grown in this hollow at different periods of antiquity.

A similar succession of three distinct series of roots of fir-trees, divided by interposed beds of root, is given by Mr. David Aher in vol. ii. of the Irish Bog Reports, page 61. Pl. IV.

6.—*Notice on Carbonate of Copper occurring in the Magnesian Limestone, at Newton Kyme, near Tadcaster. By* W. Marshall, Esq., M.G.S. [Read May 20th, 1825.

The accompanying specimens of green carbonate of copper were discovered by myself last spring in a large quarry of magnesian limestone, situated about half a mile south of Newton Kyme. The copper runs through the limestone in thin veins, dipping considerably to the west, which is also the dip of the limestone itself, but at a less angle than the copper.

That copper has been of frequent occurrence in this quarry is proved not only by the debris of the workings of later years, but also by the fact, that it is still to be found adhering to the stones in many of the oldest walls about Newton Kyme, the materials of which were taken out of this quarry.

At a small village called Farnham, about two miles north-west of Knaresborough, which is also upon the magnesian limestone, a considerable quantity of copper was formerly obtained by means of galleries worked through the limestone.

The copper, which appears to have been the green carbonate, was not only found investing the limestone, but also in small masses, seldom exceeding the size of a large potatoe.

The workings were abandoned, and the shafts (which were generally about 15 or 16 yards deep) filled up, in consequence of the great accumulation of water, which they ineffectually attempted to overcome by engines worked by horses; the disputes among the proprietors of the adjoining lands preventing them from driving a level to take away the water.

A small quantity was found so late as twenty years since, upon sinking a well through the limestone. None is ever found in the quarries now worked at Farnham.

These two are the only instances, I believe, where any of the ores of copper have been found occurring in the magnesian limestone of this country, and they appear to have escaped the notice of Geologists.

W. Marshall.

XIII.—*Remarks on the Geology of Jamaica.*

By H. T. De la BECHE, Esq. F.R.S., F.L.S.,

FEL. GEOL. SOC., HON. MEM. PHYS. AND NAT. SOC. OF GENEVA, ETC.

[Read Dec. 2nd 1825, and Jan. 6th 1826.]

THE detailed observations, which alone can establish on a secure basis the solution of those great geological problems, on which the hope of ultimately arriving at any satisfactory theory must of necessity depend, are, notwithstanding the rapid progress which geology has recently made, as yet confined to districts comparatively limited. The investigation of the order in which the mineral masses constituting the earth's surface rest upon each other, and the inquiry how far that order is invariable,—whether the remains of successive races of organized beings, which characterize the different members of the geological series, exhibit in distant countries general features of analogy, or of distinction,—and how far the action of the various geological causes, which appear to have operated in those localities with which we are best acquainted can be recognised in others,—are questions which have hitherto been principally confined to a few European countries. Even the very valuable materials which the comprehensive mind of Humboldt has accumulated, must be considered rather as indicating the extent of the field before us, than as having fully occupied any part of it.

In the present state of our knowledge, detailed monographs of particular districts, although from their very nature in themselves dry and tedious, and little calculated to attract the general reader, must necessarily precede those extensive views, which are more delightful in proportion to the higher intellectual powers which they require for their developement. In the hope of contributing in the more humble manner towards the advancement of a science to which I have been long attached, I offer the following observations; feeling at the same time that they require a few preliminary words of explanation and apology.

The minuteness of many of the details, into which I have found it expedient to enter, may appear perhaps to many unnecessarily tedious: but it must be

remembered, that in describing a remote, and, if I may so speak, a *new* geological country, in which the identification and general relations of its constituent rocks are either imperfectly or not at all illustrated by previous knowledge, there is scarcely an alternative between this and a description too vague to be useful. For example: if the geologist were describing the course of the Chalk or Oolitic series in any portion of the European basin, he would be guided at once by his previous knowledge of these formations, as to what circumstances were really material in their physical history, and what were merely subordinate and unimportant; and assuming the same general information on the part of his readers, he might dismiss the subject with all the spirit of a rapid sketch. But in treating of a formation hitherto unexamined, the White Limestone of Jamaica, for instance, the case is entirely altered: all local circumstances, then become of temporary importance, because it is only from the more extended comparison of these that their true relative value can be ascertained. With regard to faults of omission, a tropical climate may perhaps be urged in extenuation; for, not to speak of that incapacity for exertion, whether of body or mind, which it is so calculated to produce, the physical obstacles which it opposes to the researches of the geologist are neither few nor trifling. The tropical forests present not the least of these; for splendid and luxuriant as they are, they are from their very luxuriance almost impenetrable without the aid of persons to cut a path in them, the parasitical plants festooning from tree to tree, and interlacing one with the other.

As yet, no geological description has appeared of Jamaica, nor indeed of either of the large islands of Cuba, or Hayti; so that we have few or no facts previously ascertained, to guide us while investigating the rock formations in Jamaica: neither can we trace the various changes that the rocks have undergone within moderate distances, by comparing the structure of one island with the other. The geological accounts therefore which Humboldt has given us of Mexico and South America become highly valuable, as they afford us information respecting countries not very remote from Jamaica. The only private collection, I believe, of Jamaica rocks or fossils existing in England, previously to my return from the investigation which is the subject of this memoir, was in the possession of Richard Bright, Esq. of Ham Green near Bristol. This collection was made in Jamaica by his son Mr. Robert Bright a few years ago; and the inspection of it, before my embarkation, was of great use to me in directing my attention to those points in the island whence they had been procured.

The examination of rock formations in countries far distant from each other cannot fail of exciting the highest interest in the geologist; for he then has

an opportunity of observing whether or not the same causes have been in action in various parts of the earth's surface; and whether the superposition remarked in one portion of the globe, is the same with that seen in another. He moreover will see whether or not rocks exist, which are not included in our European lists: for as we sometimes find several formations wanting between two rocks in England and elsewhere, so may we find rock formations in America which are wanting in Europe; there being no more reason why in a series of rocks, represented by α, β, γ, δ, δ should not be missing in Europe, than that β should be found in England and be wanting in Germany.

The following observations will be confined to that part of Jamaica which is situated to the eastward of a line drawn from Alligator Pond Bay to St. Ann's Bay, thus taking in nearly the eastern half of the island where the most elevated mountains are found. The whole of this portion of Jamaica is hilly and mountainous, with the exception of the extensive plains of Liguanea, St. Catherine's, St. Dorothy, Vere, and the lower part of Clarendon.

The highest range in the island is that of the Blue Mountains, situated in the eastern part of Jamaica, in the parishes of Port Royal, St. David, St. Thomas-in-the-East, Portland, and St. George. Their principal direction is nearly east and west; but they do not, as is often represented, extend through the whole length of the island: for with the other mountains to the westward of the Agua Alta, or Wag Water, they have no connexion. The Cold or Main Ridge varies from about 5,000 to 6,500 feet in height, and the summit is in some places so narrow as not to be more than three or four yards across. From the northern side of part of this ridge, a curved ridge detaches itself, of greater elevation than the other; and from this curved ridge rise three principal masses, which have obtained the name of peaks, that to the east being the most conical. Robertson, in his map of Jamaica, estimates their different heights, at 8184, 7656, and 7576 feet above the level of the sea, that which he calls the northern peak being the most elevated. These heights I am inclined to think too great; for my barometrical measurements, though incomplete, would seem to give about 7600 feet for the highest peak *.

Catherine's Peak, which I found by barometrical measurement to be 4971 feet in height, forms the highest point of the mountains crossing the island from N.W. to S.E. through the parishes of Port Royal, St. Andrew, and St. George, and constituting the next highest range to the Blue Mountains. The Port Royal mountains are of considerable elevation even near the sea,

* My barometer was broken and rendered useless upon the ridge from whence the peak rose; but it had previously given me 7163 feet for the height of the ridge, and I do not think that the summit of the peak was more than 400 or 500 feet above it.

Flamstead House upon the summit of one of them being 3800 feet above its level.

To the westward of this range the mountains are of less elevation. Robertson gives the height of Lunan's Mountain to the north of Spanish Town, as 2282 feet. From Stony Hill Barracks, which I make by barometrical measurement to be 1360 feet in height, a number of mountains of nearly equal elevation extend into St. Mary's: Green Castle upon the summit of one of them being 1322 feet above the sea.

The trap mountains of St. John's attain considerable elevation, and are remarkable for sharp ridges intersecting each other in various directions; the valleys between them becoming suddenly deep, close to their commencement.

Robertson gives 3140 feet as the height of the Bull Head, an elevated portion of the mountain in the north of Clarendon, which may in some measure be considered as a western prolongation of those in St. John's. The range of the Mocho Mountains, also in Clarendon, is separated from the above by the basin drained by the mountain portion of the Rio Minho, and its tributary streams.

The Mocho Mountains are nearly of the same height as that elevated district, which being divided at the top into many small hills and valleys, has obtained the name of the Manchester Mountains. The Mocho are separated from the latter mountains by a picturesque valley several miles in length called Mile Gully, which gradually falls into the great plain of Vere and Lower Clarendon.

The greater part of the parish of St. Ann is elevated land, divided into hills and valleys in the manner of Manchester, but on a larger scale: this land attains considerable elevation at Monte Diablo, where it towers above the basin of St. Thomas-in-the-Vale. A continuation of the Monte Diablo range extends to the N.E. and separates the two parishes.

The above is the general character of the principal elevated portions of that part of Jamaica, which it is my present intention to describe. The principal plain is that of Liguanea, with its prolongation through the parishes of St. Catherine and St. Dorothy. The mountains terminate suddenly upon the Liguanea plain, which is inclined, falling gradually from a height of more than 700 feet near the Hope Tavern to the sea near Kingston. The plain of St. Catherine, bounded on the south by the Healthshire Hills, with its continuation into St. Dorothy, does not appear to be so much inclined.

The great plain of Vere and Lower Clarendon is separated from the above by a low range of hills connected with the higher mountains of Clarendon. This district is bounded on the north by the Mocho Mountains, and on the

west by those of Manchester. A remarkable hill, called the Round Hill in Vere, terminates this plain near the mouth of the Milk River, and another named Kemp's Hill rises in the middle of Vere. Portland Ridge bounds these lowlands on the S.E. This plain would not appear to be much inclined, as the works at Halse Hall estate, situated some distance inland, are only about 170 feet above the level of the sea.

Luidas Vale, a remarkable basin in the upper part of the parish of St. John, would form the bottom of a lake, were not the waters which run into and fall upon it carried off by numerous sink-holes or gulfs :—but of this more hereafter.

The elevated basin of Whitney estate, situated in the Mocho Range, is a repetition of Luidas Vale on a small scale; the waters losing themselves in sink-holes, and the river, which sinks near the works of the estate, being generally considered as reappearing on the other side of the mountain, as the head of the Milk River.

The basin of St. Thomas-in-the-Vale, now studded with sugar estates, would also form the bottom of a lake, if the rocky pass through which the Rio Cobre flows were stopped up. This defile is a break in the range of the Red Hills, and cannot fail to remind the geologist of many similar breaks in mountain chains in other parts of the world, which, if closed, would convert the districts, the waters of which they are the means of carrying off, into lakes.

A plain of some extent, covered with sugar estates, occurs between Bath (St. Thomas-in-the-East) and the mouth of the Plantain Garden River.

Few countries excel Jamaica in picturesque beauty. The great variety of its surface, added to the luxuriance of tropical vegetation, cannot fail to charm those who have visited it for the first time. Many of the valleys which take their rise in the Blue Mountain Range, more particularly those on the northern side, present a fine union of rock, wood, and water. The rivers running in these valleys are in general short and rapid, and, when swollen by heavy tropical rains, dangerous to pass. The views from the summits of many of the mountains are most splendid, particularly at sunset; and that from the top of Catherine's Peak, extending to the north and south sides of the island, is well known and easily attainable. The Blue Mountain Peaks, as might be expected, present noble and commanding views over the eastern part of the island: to obtain these, however, the traveller is in general compelled to ascend some tree, as the peaks are covered with vegetation, which in a great measure conceals the country from him.

Having thus presented the reader with a slight sketch of the scenery of Ja-

maica, I shall proceed to enumerate the different rocks, commencing with those of the oldest formation.

Submedial or Transition Rocks.

Rocks which may be referred to this class compose the principal portion of the Blue Mountain Range, and are continued in a North-east direction through the parish of St. George into that of St. Mary. They are the oldest rocks which occur in the part of Jamaica examined by me: and from the information which I have obtained, there does not appear to be any rock of equal age in the other or western portion. The boundary lines of these rocks may be described, commencing with St. Mary's, as forming the whole of the coast of the latter parish, eastward from the mouth of the Agua Alta or Wag Water to within a mile or two of Ora Cabessa Bay, with the exception of Jack's Bay, Don Christopher's Point, Blowing Point, Forster's Cove, Green Cove, Pagee Point, Fort Haldane, and the small island opposite Port Maria; in all which places the submedial rocks are covered by a part of the white limestone formation to be mentioned hereafter. The latter formation rests upon and bounds the above rocks in the vicinity of Eden estate near Ora Cabessa. From thence, after crossing a hill, the line passes at the foot of the high white limestone hills that rise above the submedial country in the neighbourhood of the Union and Ramble estates; and afterwards passes at the base of a continuation of the above high land to the vicinity of Unity and Non-Such estates. From the latter point the line is continued a little to the south of Konigsburg, and crosses the Agua Alta to the north of its confluence with the Ugly River; —in this part of its course the submedial country is covered by red sandstone and conglomerate.

Quitting the parish of St. Mary, the southern boundary line of these rocks crosses the mountains which separate the Agua Alta from the Buff Bay River to the northern face of Catherine's Peak, then enters Port Royal parish, following the course of the Yallahs River for some distance, and afterwards, skirts the base of the Blue Mountain Range through St. David's to Bath in St. Thomas-in-the-East. From the latter place, round the coast, to Port Antonio, the submedial country is separated from the sea by the white limestone formation, except near the latter place, where porphyry intervenes between them.

From Port Antonio to Annotto Bay the northern boundary line of these rocks passes at some little distance from the coast through the parishes of Portland and St. George, gradually approaching the sea as it reaches Annotto

Bay. Upon the Swift, Great Spanish, and Buff Bay rivers these rocks will be observed separated from the white limestone formation by red sandstone.

The following rocks constitute this submedial country.

Grauwacke.—This rock is well exposed in St. Mary's, and varies in its structure from a fine-grained compact sandstone to a coarse conglomerate, both occurring in beds of various thickness and occasionally interstratified with grauwacke slate of various degrees of fineness. The colour of this rock varies from gray to brown; the conglomerate contains portions of quartz, syenite, &c. from the size of a nut to three or four inches in diameter.

The road from Forster's Cove to Port Maria affords several fine sections of slaty and compact grauwacke *; the inland road from Port Maria to Islington estate does the same, more particularly near Quebec estate, between which place and Port Maria there is a good exhibition of the compact variety in thick beds. The strata of this district, though they sometimes undulate, and therefore have the appearance of inclining in contrary directions, dip generally to the S.W. at angles varying from 30° to 50°. There are, however, some thick conglomerate beds, which though of rather an ambiguous character, more resemble the grauwacke conglomerate of Jamaica, than any other rock which I observed in the island; these dip to the N. at Forster's Cove. Between the latter place and Islington, thin beds and nodules of compact grayish blue limestone occur among the grauwacke rocks. Near Albion estate, not far from Port Maria, compact sandstone beds, which appear to belong to the grauwacke series, will be observed, and between that place and Eden estate I found a compact sandstone with vegetable impressions; these were however but ill defined, and had the appearance of reeds, not of ferns. Large blocks of porphyry, with a dull green and rather earthy base containing white crystals of felspar and small grains of quartz, are found at Stony Cove: this rock would seem to be associated with the grauwacke.

The grauwacke beds on the coast at Carlton Wood House, a short distance eastward from Forster's Cove, dip at a considerable angle to the N.E., but at Agualta Vale Pen, under the hill upon which the house stands, is afforded a section of slaty and compact grauwacke beds, dipping at about an angle of 40° to the S.W.; so that the strata would appear to be arched between these two places, the latter of which is situated about five miles in a S.S.E. direction from the former.

Proceeding from Agualta Vale Pen up the Agua Alta, grauwacke occasionally composed of very thick beds of coarse conglomerate will be observed for some distance up the picturesque valley in which the river flows.

* A variety of grauwacke sandstone from Forster's Cove effervesces slightly.

The valley of the Buff Bay River affords a somewhat different section of the grauwacke. Ascending the river, and after passing some red sandstone, among which porphyritic rocks are seen, we meet with thick beds of a brownish red compact sandstone, mixed with slaty marl, and very much resembling the old red sandstone of South Wales: this sandstone gradually loses its colour, passes into gray sandstone, and becomes mixed with coarse slate, reminding the observer of the passages of old red sandstone into grauwacke in England, &c. The grauwacke continues for some distance up the river, and then seems gradually to pass into a blueish marly slate (which slightly effervesces) mixed with grayish sandstone (grauwacke) and beds of dark gray compact limestone (traversed by numerous veins of calcareous spar), which latter become more abundant after passing Belcarres.

The dip of the grauwacke beds on the Buff Bay River is to the N.E. and N.N.E., being the same with the Carlton Wood House beds: this afterwards becomes the nearly general dip of the submedial rocks composing the Blue Mountain Range.

The Great Spanish and Swift rivers present little or no section of grauwacke; the rock which succeeds the red sandstones in those places being principally composed of slaty marl with sandstone, and nodules and beds of compact gray limestone, such as occur beneath the grauwacke on the Buff Bay River.

The Rio Grande, the next great river to the eastward that cuts the Blue Mountain Range, affords sections of grauwacke closely resembling those of St. Mary's. The road from Port Antonio to Golden Vale is interesting in this respect, as thin beds of grauwacke sandstones intermixed with argillaceous slates are there observable dipping from E.S.E. to S.E.

The higher part of the Cunha Cunha road, between Port Antonio and Bath (St. Thomas-in-the-East) and over the continuation of the Blue Mountains, presents a mixture of brown and gray slaty and compact grauwacke beds, interstratified near the summit of the mountain with a conglomerate, in which the rounded pebbles are often of large size, and which evidently belongs to the same series: in fact, the mechanical origin of grauwacke is well exhibited in Jamaica, its beds varying from a fine-grained sandstone to a conglomerate, the pebbles in which are often of considerable size.

I have observed but little of this rock on the southern side of the Cold Ridge, unless indeed the gray compact siliceous sandstone mixed with slate and thin beds of gray compact limestone, occurring on the northern side of Catherine's Peak, be considered a variety of it.

Ascending the mountain from the Buff Bay River, which is commonly known

by the name of St. George's Gap, a rock is seen partly composed of a kind of marly argillaceous slate, apparently grauwacke, some of its beds resembling those found on the Agua Alta. These dip to the N.E., and therefore would appear to underlie the limestones of the Buff Bay River; they however seem mixed near the summit of the mountain with red-sandstone and red conglomerate beds, resembling those found on the Buff Bay River, to the south of Charles Town Maroon Town, and noticed above as passing into grauwacke: these red beds are the more remarkable as they also very much resemble those found on the summit and southern face of the same mountain, which would appear to constitute parts of a newer formation than the grauwacke. The beds of red-sandstone and conglomerate associated with the grauwacke on the northern side of St. George's Gap dip at a considerable angle to the N.E., while the beds on the summit and southern face of the mountain dip at a great angle to the S.W.: the dips become so suddenly altered that it is somewhat difficult to suppose them arched.

Submedial or Transition Limestone.

The Buff Bay River affords a fine section of grayish blue compact limestone, traversed by more or less numerous veins of calcareous spar, and altogether resembling, in mineralogical structure, the common submedial or transition limestones of Europe. I did not discover organic remains in it, such as belong to similar rocks in other parts of the world,—in fact I was not fortunate enough to meet with any; but occurring as it does among the rocks mentioned above, and being so completely associated with them, there can be little doubt that they belong to the same epoch of formation: and, if the sandstones, conglomerates, and argillaceous slates mentioned above were formed at the same time with the grauwacke rocks of Europe, the limestones under consideration must be submedial or transition limestones.

The upper beds of these limestones are much mixed with sandstones; the latter however gradually disappear, and the former become alone associated with a marly slate containing calcareous matter. These strata are frequently much contorted and twisted, of which the river sections afford many fine examples; no great dependence can therefore be placed on dips: it may, nevertheless, be as well to state that at Belcarres, the strata dip to the N.W., having previously dipped to the N.N.E. The marly slate becomes very abundant as we approach the ascent of the mountain to St. George's Gap, some short distance up which these strata are continued.

It should be remarked that a kind of coal is stated to have been found among the Belcarres strata. I had no opportunity of examining a specimen

from this place, but should conceive that it must be of the Anthracite kind. A similar substance, I was informed, had been found at Guatamala upon the Cave River, which flows into the Swift River, but in what rock it would be difficult to say, for there are beds of red-sandstone at that place as well as the limestone and marly beds, which cross over from the Buff Bay River. The latter rocks are exposed to view on the Swift and Great Spanish rivers; and the iron pyrites found among them on the banks of the former have been mistaken for gold.

Submedial limestones occur occasionally on the southern side of the Blue Mountain Range from the head of the Yallahs River to the neighbourhood of Bath, in St. Thomas-in-the-East, sometimes associated with sandstones and slates having a grauwacke appearance; at others, with greenstones, syenites, and other trap rocks, in a singular manner.

Thin beds of compact gray blue limestone are seen connected with slaty shale in the vicinity of Clifton (near Catherine's Peak); these dip at an angle of 45° to the E.N.E.

The Green River which falls into the Yallahs River near Green Valley Works, brings down, in its course from the Cold Ridge, a considerable quantity of compact grayish blue limestone, which shows that this rock occurs in this part of the Blue Mountains*. Blueish-gray limestone may also be observed near Green Valley.

Abbey Green, St. David's, situate on the southern side of the Cold Ridge, is one of the highest coffee settlements in Jamaica: the house upon it I make by barometrical measurement to be 4233 feet above the level of the sea. At this place submedial limestone of a gray colour, and traversed by veins of calcareous spar, will be found associated in a rather singular manner with syenite, greenstone, grauwacke, and argillaceous slate, the superposition of one above the other being very indistinct; so that little can be learned from this spot, which would, if a better section were afforded, be highly interesting in a geological point of view, as the limestone is here seen close to the trap rocks, and does not appear, from what is exposed by section, to have suffered much if any alteration.

Not far from Portland Gap (a depression in the Cold Ridge which I esti-

* The meeting of the debris of the Yallahs and Green rivers is singular, and strongly reminded me of the effect produced by the meeting of the Rhone and Arve near Geneva, where the blue waters of the one and the discoloured glacier waters of the other do not immediately mingle, but flow side by side for some distance: so it is with the debris brought down by the two Jamaica rivers; that of the Green River is blueish from the slates, limestones, &c. which it traverses, and that of the Yallahs River reddish, from the red-sandstones and conglomerates which it washes.

mate from barometrical observations to be 5642 feet above the sea), and on the road to that place from Abbey Green, I found a large block of grayish white limestone approaching the crystalline or saccharine character, and somewhat resembling the primitive limestones; it was however most probably derived from some bed associated with the submedial rocks of the district, which is concealed beneath the thick foliage of the tropical forest that rises above the spot where the block is found.

Sections of submedial limestone are afforded near Bath in St. Thomas-in-the-East: the best is that seen between the village and the hot spring, up the valley of the Sulphur River; a dark lilac-coloured compact limestone will be there observed connected with trap rocks and argillaceous slate. The Bath mineral spring, (the heat of which I found to be $=127°$ Fahrenheit, the thermometer being plunged into the spring itself,) rises from a mixture of argillaceous slate and thin beds of compact gray limestone; trap rocks being however not far distant.

The first part of the ascent of the Cunha Cunha road from the Plantain Garden River presents a continuation of the beds exposed in the valley of the Sulphur River, a lilac-coloured limestone traversed by veins of calcareous spar being associated with argillaceous slate and trap. Higher up the mountain on the same road, a light gray limestone of very compact texture is seen forming part of the submedial country.

Argillaceous Slate.—I did not observe that this rock constituted by itself any considerable portion of the submedial or transition country of Jamaica; the variety, commonly called grauwacke slate, occurs however in considerable abundance in the parish of St. Mary, in some places not much mixed with the thick and compact grauwacke beds.

Argillaceous slate may occupy considerable space in the Blue Mountains, for there were many sections of this range which I had no opportunity of examining. This slate is found not only in those places where this rock has been mentioned as occurring associated with others, but also beneath the white limestone formation on the ridge which separates the Morant from the Plantain Garden River, between Spring and Whitehall estates. It is also seen mixed with trap rocks in the bed of the Plantain Garden River from the latter place to Bath.

The mass of marly slate which occurs with the limestones from Belcarres on the Buff Bay River to the St. George's Gap Mountain can scarcely in strictness be called argillaceous slate, and therefore cannot fairly be classed under this head: it however forms so considerable a portion of country, and is such a conspicuous feature in the geology of this part of Jamaica, that it scarcely deserves to be considered as subordinate to the limestones.

Micaceous Slate and Hornstone.—The latter interstratified in thin beds with argillaceous slate of a micaceous lustre, is found on the ascent of the Blue Mountains between Green Valley and Sheldon. The hornstone is striped, and sometimes splits into a slate resembling flinty slate. These strata dip to the N.E. at angles varying from 60° to 70°, *apparently* beneath the mass of rocks which are crowned by the Blue Mountain Peaks.

A light-coloured sandstone is met with between Charlottenburg and Islington in the parish of St. Mary, which differs from the grauwacke of the country, and indeed from any grauwacke I have ever seen; yet as it occurs among this submedial district, and does not appear connected with any secondary rock, its place would seem to be among the class of rocks under consideration: and I may also observe that there are some other strata in the same parish, particularly slaty brown marls with thin seams of white occasionally associated with them, which it would be difficult to separate from the grauwacke of Jamaica, though they differ from the grauwacke of Europe. These strata are observable in one or two places between Charlottenburg and Islington, as also on the mountain between Albion estate near Port Maria, and Eden near Ora Cabessa.

In the whole of this submedial or transition country I was not fortunate enough to meet with any fossil organic remains, except the vegetable impressions of the sandstone in the mountain between Port Maria and Ora Cabessa. I may therefore be asked why I have named the limestone associated with these rocks, transition or submedial limestone?—I can only reply, that it mineralogically resembles the transition limestones that I have seen in various parts of Europe and Great Britain, and that it occurs with a sandstone and conglomerate very much resembling grauwacke, with argillaceous slate, syenites, greenstones, &c., in fact associated as submedial limestones often are in other parts of the world.

It should be remarked of this group of rocks, that the most general dip of the mass composing the Blue Mountain Range is to N.E. and E.N.E., most commonly at a considerable angle, which dip is continued into the northern part of St. Mary's parish near Carlton Wood House, but further north in the same parish the dip becomes reversed, and is to the S.W.; it continues S. or S.E. along the line of junction with the red-sandstone and conglomerate to the Agua Alta, so that the strata would seem to be arched in some parts of St. Mary's: the rocks however on the northern face of Catherine's Peak dip to the N.E.

The submedial strata of the eastern part of the island have a tendency to

dip towards the sea in that direction: thus the grauwacke between Port Antonio and the Rio Grande, in the vicinity of Golden Vale estate, dips to the S.E. and E.S.E.; and some of the beds on the Cunha Cunha road sink to the eastward.

Trap Rocks associated with the Submedial Rocks.

Although it by no means follows that, because trap rocks are associated with submedial rocks, they should be of the same age with them, or formed at the same geological epoch; yet as a matter of convenience it may be as well to notice here the rocks of this nature, occurring among the submedial rocks of Jamaica, though they very much resemble other trap rocks of the same island, which are connected with a porphyritic conglomerate of more recent formation, to be mentioned in the sequel. That we should not always refer trap rocks to a more distant period of formation than the rocks which appear to rest upon them is well shown in the section afforded by the cliffs near Gouldtrop Road in Southern Pembrokeshire, where greenstone, passing into syenite, rises from beneath old red-sandstone, which seems to rest upon it, although a continuation of the same trap afterwards rests upon contorted carboniferous limestone and coal measures opposite to the anchorage in Gouldtrop Road: so that the same trap seen at one end of its course might be asserted (judging only from position) to have been formed at a period antecedent to the old red-sandstone; while, viewed at the other, it might be declared to be a newer formation than the carboniferous limestone and coal measures. So it might happen with the trap of Jamaica, which might easily have been thrown up among the submedial rocks at the same period with the trap occurring among the newer rocks; yet as an abundance of pebbles, evidently derived from trap rocks, are found among the red conglomerates which cover the submedial rocks of Jamaica, it is fair to infer that trap must have been associated with these latter rocks previous to the formation of the conglomerate. There seems, moreover, every reason to suppose that trap rocks, notwithstanding their general similarity of structure, have been formed at distant and distinct periods; one of these periods seems to have been that when the submedial or transition rocks were formed, and to this period may probably be referred that portion of the Jamaica trap rocks which I am about to mention, though, from the want of good sections, their connexion with the submedial rocks of this island is rather obscure.

I observed trap rocks in considerable abundance upon the southern side of the Blue Mountain Range; also upon that portion of it known as the Cold Ridge, and in the highest parts of the Blue Mountain Peak. Ascending

towards the Blue Mountain Peaks by Sheldon, Abbey Green, and Portland Gap, I observed syenite, composed of white and flesh-coloured felspar, colourless quartz, and greenish black hornblende, in considerable abundance between Sheldon and Abbey Green, near Farm Hill: this syenite seemed to be associated with grauwacke; in what manner, however, it would be difficult to say, as their relative position was very obscure.

Greenstone (white felspar, and blackish green hornblende, the grains being of a moderate size) is seen singularly mixed up with slate and limestone immediately above Abbey Green House; and between this place and Portland Gap, an association of porphyry, slate resembling grauwacke slate, greenstone and limestone will be met with. The porphyry is principally of a dark claystone or trappean base with white crystals of felspar varying in size in different places.

The ridge which extends from Portland Gap to the base of that from which the Blue Mountain Peaks rise here and there, presents, where the tangled and moss-covered roots will permit a portion of rock to appear, that variety of trap which is not unfrequently observable in districts composed of this class of rocks; it is not precisely a cornean, but in some instances approaches it; it occurs of a dark colour on this ridge, and gives out an earthy smell when breathed upon.

On the ridge from whence the highest Blue Mountain rises, I found a dark-coloured trappean rock, containing a very few small crystals of felspar in the mass; it gives out an earthy smell when breathed on, and occasionally has a sandstone appearance: the Peaks seemed in a great measure composed of a similar substance. I did not observe any greenstone, syenite, or porphyries upon the higher parts of the Cold Ridge or Blue Mountain Peaks, but merely the above rocks; their connexion with well characterized trap is therefore not clear, and they may be mere varieties of grauwacke or some other submedial rock, though from their general appearance, and their resemblance to rocks in some trappean districts elsewhere, I am inclined to refer them to the trappean class.

Trap will be observed mixed with argillaceous slate and grauwacke at the base of the Blue Mountain Range, between Whitehall and Bath (St. Thomas-in-the-East); it is exposed in the bed of the Plantain Garden River, and is principally composed of a dark claystone porphyry, with crystals of white felspar, and of a rather earthy rock, of a gray, greenish, and occasionally reddish colour, traversed by numerous veins of a substance having a zeolitic character. This rock forms some picturesque cliffs upon the river, and presents no appearance of stratification.

Trap rocks occur, as before mentioned, mixed with limestone and grauwacke, on the first part of the ascent of the Cunha Cunha road from Bath, and in the valley of the Sulphur River between the latter place and the Hot Spring. The trap in these places is principally that last noticed, varying in colour, but not so much crossed by zeolitic veins as on the higher part of the Plantain Garden River.

Medial or Carboniferous Rocks.

It is not without some hesitation that I refer the following rocks to this class, particularly as I have only observed the strata, which more immediately lead me to do so, in one place; these however so much resemble the coal measures of Europe in mineralogical structure, that, though confined to a small place, I conceived it would be better to class them for the present in this order.

But to commence with the lowest rocks, or those which rest upon the submedial country above noticed. On the Southern side of Catherine's Peak, and in the higher part of the valley of the Hope River which descends from it, a series of compact sandstone and conglomerate rocks principally of a red colour, will be observed: there are others which are gray, but they are more or less subordinate to the red. The sandstone varies in texture from extremely hard and compact to rather friable; the conglomerate also varies in its degree of hardness.

Under Greenwich Hill a very good section is obtained of these strata, which dip at about an angle of 40° to the S.W., and therefore appear to rest unconformably upon the limestones, gray sandstones, and shaly slate of the northern side and summit of Catherine's Peak. The beds vary in thickness from 4 to 12 feet, and are almost all red; the sandstone is mostly siliceous and compact; there are however beds of a marly red sandstone, and marl, insterstratified with the compact sandstones and conglomerates, which latter are composed of rounded pieces of granite (colourless quartz, reddish and white felspar, and black mica), large-grained greenstone, syenite, quartz, hornstone, &c. from the size of a walnut to three or four inches in diameter. These beds with those of slaty sandstone, mixed with beds of compact gray siliceous sandstone seen, on the ascent of the mountain, crowned by Catherine's Peak, seem to compose the lowest part of this formation; which appears to be of considerable thickness, judging from the section afforded by the valley of the Hope River, and, but for the very great difference of dips, would seem to pass into the submedial class.

But to continue the Hope Valley section.—At Middleton House, which I es-

timate, from barometrical observations, to be 2340 feet above the level of the sea, thick beds of very compact gray siliceous sandstone are seen forming a high cliff to the west of the house* ; these strata cross the river, into the bed of which large blocks of sandstone and the conglomerate have fallen.

There are some marly strata above Hopewell, a little further down the river than Middleton, in which veins of white and rose-coloured gypsum occur ; these strata are mixed with others of sandstone, and the whole seems to constitute a part of the same formation with the red and gray sandstones and conglomerates composing the upper portion of the Hope Valley section ; for rocks similar to the latter again come in between Hopewell and the limestones of Mount Pleasant. The beds here mentioned present a mixture of thick strata composed of siliceous sandstones, with conglomerates, formed of rounded pieces of older rocks, and cemented by the same kind of siliceous sandstone, occasionally interstratified with slaty sandstone. The dip of these strata is generally at a considerable angle to the S.W., they are in some places perpendicular, and appear to have suffered much disturbance.

At Mount Pleasant a blackish gray compact limestone comes in, some of the beds of which are traversed by numerous veins of calcareous spar, in general appearance very much resembling many beds of the carboniferous limestone in the vicinity of Bristol, such as that of Clifton, &c. I observed what appeared to be encrinal remains in the Mount Pleasant limestone, as also sections of bivalve shells. These limestone beds dip at about an angle of 75° to the eastward, which is by no means conformable to the mass of red-sandstone and conglomerate rocks in which they seem in some measure included ; yet a collection of similar limestones, not much more in the whole than 50 or 60 feet thick, crosses a valley near the Mount Pleasant beds in an East and West direction, and seems to be connected with them. The same kind of limestone beds are found near Flamstead House, in the Port Royal Mountains. The dip is not clearly shown at this place ; but the limestones are associated in the same manner as those near Mount Pleasant, and appear to be a continuation of them ; for patches of compact gray blue limestone may be seen in several places between Flamstead and the Botanical Garden. Now Mount Pleasant is situated in a north-westerly direction from Flamstead, and this is precisely that of the red-sandstones and conglomerates of the district, for their direction is N.W. and S.E. ; so that the Mount Pleasant limestones may be referred to the place I have assigned them, notwithstanding the dip. Thick beds of yel-

* The mountain which rises to the west of the house, and of which this cliff forms a part, is, according to my barometrical observations, 3752 feet above the sea.

lowish and decomposed sandy rock occur in the vicinity of the above limestones both at Flamstead and Mount Pleasant. The limestones of the latter place appear to be succeeded for a short distance by sandstones and conglomerates, resembling those above mentioned.

Next in order above these appear, nearly opposite the Botanical Garden, a series of shale, schistose sandstone, and more compact sandstone beds which very closely resemble, in mineralogical structure, the coal measures of some parts of England, and the probability of their being such becomes the greater, from the circumstance that thin seams of coal are observed among them. I met with only three of these seams of not more than an inch, and an inch and a half in thickness; how numerous they may be, it would be difficult to say, as the section presented was of no great size; yet I do not suspect that there are any beds of this substance that would be worth working for useful purposes.

The general dip of these beds is to the S.W., sometimes at a considerable angle; they therefore dip conformably with the sandstone and conglomerate rocks on which they seem to rest*. I searched in vain for the vegetable impressions, generally termed coal plants, from being found among the true coal measures, which these beds nevertheless very much resemble: they are covered by a brownish red conglomerate principally composed of rounded pieces of porphyry, mixed with pebbles of other trap rocks, sandstones, &c., the whole being associated with porphyries and trap rocks. This conglomerate would appear referrible to the same epoch of formation as the *rothe todte liegende* of the Germans. According to some geologists the whole of the rocks here enumerated might be included under the head of red-sandstone (*grès rouge*), the coal measures being merely subordinate. Humboldt conceives that "le grès houiller et le porphyre constituent une même formation (*rothes todtes liegende*), variable d'aspect, et d'une structure souvent très-compliquée †;" and D'Aubisson states that "la grande formation de grès houiller se divise très-convenablement en deux parties; l'une comprend le *terrain houiller* proprement dit; et l'autre le grès, appelé, dans la Thuringe, *grès rouge*, avec ses couches subordonnées: mais tout en distinguant ces deux parties, nous remarquerons qu'elles appartiennent à la même formation; et quoique le terrain houiller soit le plus souvent au-dessous, il lui arrive quelquefois d'être entremêlé, et même d'être superposé au grès rouge ‡." The same author again remarks, that "le grès, masse principale du terrain houiller, prend

* The beds are continued across the valley of the Hope River, and will be observed forming a cliff near the Botanical Garden.

† Essai Géognostique sur le Gisement des Roches dans les Deux Hémisphères, p. 205.

‡ Traité de Géognosie, vol. ii. p. 263.

souvent une grande extension, en abandonnant, au moins en majeure partie, la houille avec l'argile schisteuse qui l'enveloppe, et il constitue des terrains d'une grande étendue. Il a été principalement observé en Thuringe, où il est connu sous le nom de *rothe-todte-liegende* *."

Viewing these sandstones and conglomerates in the manner of many continental geologists, they would form one mass with the porphyritic conglomerate to be mentioned hereafter. Humboldt considers the whole as one formation when describing the *grès rouge* of New Spain, Venezuela, New Grenada, the plateau of Quito, Peru, and the banks of the Amazon †, which the Jamaica rocks under consideration will be found very much to resemble.

Dr. Buckland and Mr. Conybeare remark on this subject ‡, that "in the south-western coal district of England we have three formations of red sandstone, the *newer red sandstone*, the *millstone grit*, and the *old red sandstone*, all liable to be confounded with one another owing to their prevailing red colour, and to their containing beds of conglomerate; and as similar rocks occur, very similarly placed, in various parts of the earth's surface, we find three opinions maintained concerning red-sandstone, and each moreover supported by indisputable facts: one that it lies over the coal measures; another, that it lies beneath them; and a third, that it is a member of the coal formation."

* * * * * * * * * * *

"The *millstone grit* affords the best example in the south-western coal-field of a red sandstone belonging to the coal measures. But occasionally even in this coal-field, and very frequently in the coal districts on the continent, all the coal-grits acquire a red colour; and for this reason we now find it to be the prevailing opinion among the continental geologists, that the *grès rouge* is a member of the coal formation."

In fact supposing the red conglomerate occurring between the magnesian limestone and coal measures, the latter and the old red sandstone to come together, the carboniferous limestone being wanting, and the coal-grits generally red, it would be most difficult to say where the one begins or the other ends; and I consider this to be the case in Jamaica: for although in the valley of the Hope River, the rocks, which I take to represent the coal measures, do present a marked appearance for a short space, they seem included among the red sandstones.

With regard to the other places in Jamaica where I have observed the red

* Traité de Géognosie, vol. ii. p. 306.

† Essai Géognostique, &c.

‡ In their paper on the South-western Coal District of England: Geological Transactions, New Series, vol. i. p. 314 and 315.

sandstones and conglomerates, the map will express better than words, the space occupied by them; I shall therefore only offer remarks on those places where sections may in some measure be obtained.

Upon the summit of St. George's Gap thick beds of red sandstone are observable, which with numerous similar beds interstratified with red conglomerates dip to the S.W. on the southern side of the mountain; and, as before observed, strata, which bear considerable resemblance to these, are found associated with the submedial rocks on the northern face of the same mountain: this circumstance would make it appear probable that the red sandstone passes into the grauwacke, if it were not for the very sudden change of dip in the two red sandstones on both sides of the mountain.

Descending from St. George's Gap to the Kingston plain on the south, beds of red sandstone and conglomerate are met with, precisely resembling those that occur on the Hope River, of which indeed they form the continuation, St. George's Gap being part of Catherine's Peak ridge. These are succeeded and covered by a light-coloured sandstone, most probably the same that occurs near the limestone and coal measures on the Hope River, I did not however perceive any of the latter rocks on the descent from the Gap.

The Agua Alta or Wag Water presents a section of red sandstones and conglomerates, which would appear to be a continuation of those above described, and which are particularly interesting, as an evident passage takes place between them and the grauwacke sandstones and conglomerates of St. Mary's. The road from Annotto Bay to Scot's Hall (Maroon Town) traverses some elevated land in order to avoid a great bend in the Agua Alta, where the Ugly River flows into it. The grauwacke which is here principally composed of thick conglomerate beds contains a few strata of a red colour; these afterwards become more numerous to the exclusion of the gray beds; slaty beds of the latter colour may however be occasionally observed among the red sandstones some little distance to the south of the elevated land. These rocks therefore seem to pass into one another; in fact the change is at first scarcely more than that of colour, the component parts of the gray and red beds closely resembling each other.

The lower beds of old red sandstone sometimes graduate (as is well known) into grauwacke upon which it reposes; therefore, if the St. Mary's rocks be considered as grauwacke, we may not unfairly conclude that the sandstones and conglomerates of Scot's Hall (Maroon Town) represent the old red sandstones of the English series. From the circumstance of old red sandstone passing into grauwacke it is usual for continental geologists to consider it as a variety of the latter rock: Humboldt does so in his "*Essai Géognos-*

tique sur le Gisement des Roches," (p.157,) and divides it from the *grès rouge* of the French and the *rothe todte liegende* of the German geologists, to which latter rock an eminent British geologist considers it should be referred *. A short distance to the south of Scot's Hall (Maroon Town) these sandstones and conglomerates disappear, and are succeeded by trap rocks; their dip varies, but is principally to the southward; I observed it once S.E. on the elevated land where these beds pass into grauwacke.

At Green Castle, situated on a mountain a short distance westward from Scot's Hall (Maroon Town), these red sandstones and conglomerates are well exposed, as also between Green Castle and Konigsburg estate. The conglomerates in these places are principally composed of rounded pieces of trappean rocks, and among the latter are greenstones and beautiful porphyries: the beds dip at about 45° to the S.W. near Green Castle, but they are nearly perpendicular not far from the same place. On the road to Konigsburg the strata dip in some places to the N.W. Among the contents of a conglomerate bed near Green Castle House, I found a rolled agate and a rounded piece of green carbonate of copper.

A considerable number of porphyry pebbles are found in the conglomerates on the banks of the river by which the road passes from the Green Castle to Konigsburg; this causes the rock more to resemble the red conglomerates of Teignmouth, &c. in Devonshire, than old red sandstone; yet as porphyries are much mixed with those Jamaica rocks that are inferior to it, more particularly in the Blue Mountain district, there seems no reason why rolled pieces of that substance should not occur abundantly in these conglomerates, which rest on them.

A passage of these rocks into the grauwacke-looking rocks of St. Mary's will be observed near Konigsburg, where the red beds become extremely marly, and pass into a gray shaly slate much mixed up with the grauwacke of St. Mary's. After all there may be a mixture of *rothe todte liegende* and old red sandstone in this district, between which it would be almost impossible to distinguish.

* The term *new red conglomerate* is no doubt a bad one for the red conglomerates that occur between the coal measures and the magnesian limestone, as it would seem to imply a connexion, with the new red sandstone (the *bunter-sandstein* of the Germans, and *grès bigarré* of the French); now the latter and the red conglomerates in question are separated by the whole mass of the magnesian limestone (*calcaire alpin*, *alpenkalkstein*), and therefore constitute two separate formations, which may however come together, the magnesian limestones being wanting, as is probably the case in Devonshire: indeed the red conglomerates of Exeter bear so much resemblance to the German *rothe todte liegende* that I should propose the name of *Exeter conglomerate*, as the English equivalent to the latter rock.

On the Buff Bay River, and on the Southward of Charles Town, there are thick beds of red sandstone and conglomerate, which pass, as before stated, into the submedial rocks of that district; these beds very much resemble those at the head of the Hope River, and very probably belong to the same epoch of formation.

Among the Port Royal Mountains a considerable quantity of these rocks will be observed, closely agreeing in composition with the red sandstones and conglomerates of the Hope River, of which in fact they form the continuation.

Between Guava Ridge and the Yallahs River, but nearest the latter place, there are thick beds of very compact siliceous sandstone, which apparently belong to the red sandstone formation of Jamaica; some parts of it are so quartzose as to resemble M. von Humboldt's description of his "*Roche de Quartz Secondaire**," which he mentions as occurring in the Andes of Peru between the 7th and 8th degrees of southern latitude. He states that this rock is less developed on the eastern than on the western side of these mountains, and that on the latter it is many thousand feet thick, and replaces the *grès rouge*.

Near Cocoa Walk estate on the Yallahs River, St. David's, twisted beds of brown conglomerate, in which porphyry pebbles are abundant, are seen by the road side on the right bank of the river; these are much mixed with slate clay, which is also twisted and contorted, and resembles that found among the coal measures of the Hope River. These rocks are also observable on the left bank beneath a mountain capped by the white limestone formation, and the whole of the conglomerate and slaty beds are referrible to the rocks under consideration.

Supermedial, or Secondary Rocks.

Porphyritic conglomerate associated with Porphyry and other Trap rocks.—These rocks would, according to the views of those geologists who consider red sandstone (*grès rouge*) as one great formation, in which coal measures are subordinate, be classed with the red sandstones and conglomerates above noticed. I have however here separated them, as they are, in Jamaica, associated in a remarkable manner with porphyry and trap rocks, which the others are not.

The great characteristic of the conglomerate is, that the pebbles contained in it are principally, and in some cases entirely, composed of various kinds of

* Essai Géognostique sur le Gisement des Roches, p. 231, &c.

porphyry, and are almost always of some kind of trap rock. The cementing matter is most frequently a reddish brown argillaceous substance of various degrees of hardness; and the cement is in some places so obscure, that the pebbles have the appearance of being joined together by a trappean substance.

I refer these rocks to the same epoch of formation as the porphyritic conglomerates of Exeter and Teignmouth, which are by many considered as the English equivalent to the German *rothe todte liegende*, or that part of it which rests upon the coal measures. The rocks of this geological epoch are often, as is well known, found associated with porphyry, which has obtained the name of *Porphyre secondaire* with the French, and *Porphyr gebirge* with the Germans. In like manner the porphyritic conglomerate of Jamaica is so much mixed with porphyries and other trap rocks, that it will be necessary to describe them together.

The rocks cover what I have considered as coal measures nearly opposite the Botanical Garden on the Hope River, and continue from thence to where the valley opens upon the Liguanea plain near the Hope Tavern. Most of the conglomerate beds are here of a reddish brown colour, and are composed of rounded pieces of porphyries (principally claystone), of various greenstones, and other trap rocks, cemented by an argillaceous substance, which in some cases passes into a kind of trappean claystone: the general dip of the beds is at about an angle of 45° to the S.W., and their thickness varies from two to ten feet. These strata are associated in an obscure manner with porphyry. In one place the latter rock, with a dark claystone base containing crystals of white felspar, has the appearance of a bed interstratified with the conglomerate; but this may, as Dr. MacCulloch has shown, easily occur without the porphyry or trap actually forming a bed.

Not far from the Hope Tavern there is a porphyry, with a reddish brown trappean base containing white crystals of felspar, and higher up the valley there is another with a compact felspathic base containing crystals of white felspar and a few small grains of quartz.

By reference to the accompanying map, it will be seen that trap and porphyritic conglomerate extend from that mentioned on the Hope River northwesterly into St. Mary's, and south-easterly through Port Royal parish to the Yallahs River in St. David's. I shall in the first place enumerate the rocks and the changes they undergo in this range of country, which for some distance separates the red sandstones and conglomerates from the white limestone formation, occurring beneath the latter and above the former.

On the lower part of the descent from St. George's Gap to the plain of Liguanea brownish red porphyritic conglomerate agreeing with that of the

Hope Valley covers the red sandstones and conglomerates, and is here and there mixed with greenstone. Apparently resting upon this, and on the lowest part of the descent, a considerable mass of syenite comes in, very closely resembling that found among the submedial country between Sheldon and Abbey Green, though here associated with more recent rocks: this syenite plunges beneath the inclined diluvial plain of Liguanea, which abuts against it, a few occasional patches of white limestone only intervening.

The Agua Alta presents a good section of these rocks between the northern base of Stony Hill and Scot's Hall (Maroon Town): near the former place brownish red porphyritic conglomerate occurs beneath the lower marls of the white limestone formation, and is succeeded by porphyries and other trap rocks of various composition and structure; the whole of which may be considered as one great mass with sometimes one ingredient predominating and sometimes another.

It should here be remarked that the trap of Jamaica is often very much decomposed to a considerable depth *, so as not to be always immediately recognised; but by careful examination hard portions will be found forming cliffs, beds of rivers, &c. where the structure can be examined. This decomposition of the Jamaica trap principally takes place in those varieties in which felspar forms a considerable portion of the mass; it would therefore seem to arise from the decomposition of this mineral, which has given way before the effects of a tropical climate.

A mountain of syenite composed of greenish black hornblende, flesh-coloured felspar, and colourless quartz, the latter mineral being rare, rises above Golden Spring estate (St. Andrew's) on the Agua Alta: this syenite resembles that of the descent from St. George's Gap, and is most probably a continuation of it. To enumerate all the varieties of trap found on the Agua Alta would be tedious; it will be sufficient to state that porphyries, greenstones, and syenites seem to pass into each other. One rock however which occurs about two miles south from Scot's Hall (Maroon Town) deserves attention, being wholly, or very nearly so, composed of two varieties of felspar, differing in colour, so as to have the appearance of syenite at a short distance. This rock would seem referrible to that variety of compact felspar which Dr. MacCulloch denominates "crystalline-granular †:" the felspar however of the rock in question is common, not compact; but as that author remarks that "it seems doubtful whether this variety does not sometimes consist of an aggregation of common instead of compact felspar ‡," it appears to be a rock of that class.

* From this circumstance it is often known in the island by the name of *Rotten Stone*.

† Geological Classification of Rocks, p. 496. ‡ Ibid. p. 497.

The road over the hills from Stony Hill to Green Castle (St. Mary's) presents trap rocks closely resembling that afforded by the Agua Alta, being not far distant from it. Between Belmont (St. Andrew's) and Green Castle I observed a porphyritic rock having a light brown earthy base containing crystals of whitish felspar, a few pieces of green hornblende, and a few specks of mica. Between the latter places I also found some masses of a steatitic rock mixed with trap, which latter was much decomposed to some depth throughout the greater part of this district.

In several places the trap had a sandy appearance arising from the decomposition of clinkstone, which, Dr. MacCulloch observes, "frequently acquires an arenaceous aspect on the surface after exposure to the weather; so as even to have been confounded with sandstone by incautious observers*."

At Pimento Grove, a coffee settlement between Rio Magno Pen (St. Thomas-in-the-Vale) and Tremolesworth (St. Mary's), trap rocks are met with, which apparently are continued from those above mentioned. They here constitute mountains that rise among others of the white limestone formation, which latter rests upon and covers the trap on the North-east and South-west. The trap in the vicinity of Pimento Grove principally consists of greenstone and porphyry. One singular variety of the latter composed of a dark claystone base studded with crystals of white felspar, will be observed on the left hand side of the road, having the porphyritic pieces or concretions rounded and separated from each other by a soft argillaceous substance, among which strings of chalcedony are sometimes found. The above is the only instance of this kind of structure that came under my observation while in Jamaica, with the exception of part of an extinct volcano to be mentioned hereafter. Here the porphyry is of a very common kind, and is associated with greenstone porphyries: one of these contains brownish red crystals of felspar, and crystals of augite; and another, grayish white crystals of felspar with crystals of augite; the last mineral being more abundant in the latter than in the former of these varieties.

In the neighbourhood of Williamsfield and Sandy Gully (St. Thomas-in-the-Vale) greenstone and porphyry, very much decomposed where exposed to the weather, form the lower parts of the valley, which has all the characters of a valley of denudation, the higher parts of the mountains being capped by white limestones, which seem once to have formed parts of the same mass. This trappean country appears to be connected with that range of trap, above described, which extends from St. David's north westerly into St. Mary's; its

* Synopsis of the Overlying Rocks, in his Geological Classification of Rocks, p. 495.

junction with it being concealed by the white limestone formation on the East of Williamsfield, &c. Another portion of decomposed trap appears on the road between Williamsfield and Hampshire * estates.

A small portion of porphyritic conglomerate occurs near Mount Sinai estate, on the Yallahs River, being a continuation of the Hope River porphyritic conglomerates on the South-east; it is however greatly covered up on the Yallahs River by the white limestone formation.

Another extensive district of trap rocks, constituting the principal part of the St. John's Mountains, and extending westerly into Clarendon, occurs at a considerable distance from that which has been above described, and is surrounded on all the sides which I have examined by the white limestone formation: it however seems referrible to the same epoch of formation as that above noticed. Ascending the St. John's Mountains by the road from St. Dorothy's Rectory to Luidas Vale, trap appears on the northern side of the river near Mountain River estate, forming the greater part of the mountain on which the Barracks are placed. Greenstone and porphyry are here seen in general very much decomposed, as is very commonly the case in the St. John's Mountains. Among these rocks I found a very fine-grained greenstone, as also a purplish brown rock, apparently with a decomposed felspathic base, in which were a few light greenish spots of decomposed felspar. The porphyries are in such a state of decomposition to a considerable depth, that their various bases cannot be distinguished without considerable difficulty: I however met with one fragment having a blackish green claystone base, with crystals of greenish white felspar. This trap mountain is covered towards Luidas Vale by the white limestone formation, which also occurs in patches upon it, as may be seen at the Barracks, &c.

A decomposed trap rock occurs at Pleasant Hill among these mountains; and this spot is interesting, as the trap can be observed almost in contact with the white limestone that bounds it on the northward, and forms the slope of the mountain towards Luidas Vale.

That part of the St. John's Mountains which is represented on the map as composed of the rocks under consideration, may be described as formed of various claystone porphyries, greenstones, and rocks approaching the basaltic character, with various modifications of that rock "of which," says Dr. MacCulloch, "indurated clay or wacke may be placed at one extreme, and compact felspar at the other; the intermediate member being claystone and clink-

* I am not quite certain of the name of this estate; it is however a little to the left of the road between Williamsfield and Rio Magno Pen.

stone *." These rocks pass into each other in such a manner that it is impossible to say what extent of country is occupied by any one. They are well exposed on the Juan de Bolas Great River, forming picturesque cliffs of various heights on both banks. Considerable variety will be found in the vicinity of Lemon Hall estate on this river. The porphyries are there principally composed of a dark claystone base with white crystals of felspar; the base of some have the appearance of a fine-grained greenstone, and I observed one with a brownish red claystone base and reddish white crystals of felspar. Among the other trap rocks of this place I remarked a fine-grained greenstone-looking rock containing small brilliant facets, which effervesce and appear to be carbonate of lime.

The trap mountains of St. John's attain considerable elevation, and are formed into very sharp ridges winding considerably, the course of the main ridges being about East and West.

The St. John's trap extends into that part of Clarendon which is principally drained by the mountain portion of the Rio Minho, and the streams descending from the elevated land of which the Bull Head forms the highest part. Porphyritic conglomerate is seen stratified near Savoy estate (Clarendon), with a dip of a few degrees to the Eastward: the same rock, which corresponds with the porphyritic conglomerate of the Hope River, is also found at Morgan's Valley. Porphyry appears to be associated with the conglomerate near Savoy estate.

A porphyry occurs near Port Antonio (Portland), separating the white limestone from the submedial rocks; but the manner in which it is exposed makes it difficult to refer it to any particular epoch of formation. This rock will be observed not far from the town on the road to Moore Town (a Maroon town); it consists of a reddish gray earthy claystone base, with crystals of white felspar, and crystals of augite. Not far from this there is another porphyry having a reddish brown claystone base, containing small reddish crystals of felspar intermingled with moderately sized crystals of augite.

To this list may be added the earthy claystone rocks which are found in one part of the descent from Monte Diablo into St. Thomas-in-the-Vale, and form some part of the southern face of that mountain; among them may be seen a porphyritic rock composed of a light brown earthy base thinly sprinkled with white crystals of felspar. From the information I received it would

* Geological Classification of Rocks, p. 480.

seem probable that trap forms the southern part of the mountain range which extends from Monte Diablo towards the north-eastern part of St. Thomas-in-the-Vale.

Superior or Tertiary Rocks?

To this order, the *white limestone formation*, which occupies such a considerable portion of Jamaica, would seem, if we only take into consideration the character of its fossil organic remains, in some measure referrible. Still however I have many doubts upon the subject; and therefore, while I class it for the present under the above head, I wish it to be understood as merely a temporary arrangement. This formation is principally composed of white limestone, varying considerably in its texture, which is most frequently very close; and, when so, strongly resembling the compact varieties of the Jura limestones, such as they occur among the Jura Mountains, and in the lower part of the Mont Salève near Geneva: in fact, specimens from the latter place, and from some of the Jamaica white limestones, present scarcely any difference. The white limestone of Jamaica is not however, taken generally, of an homogeneous composition, some parts of the same stratum being more argillaceous than others; these latter parts becoming decomposed by the action of the atmosphere, the surface is full of inequalities, from which circumstance the name of *honey-comb rock* is very generally applied to it by the Jamaica colonists. In consequence of the decomposed surface of the rock, and the thick forests by which it is generally covered, the stratification is often very difficult to determine. The strata are moreover often of very considerable thickness,—from 10 to 20 feet. This compact white limestone is, in some districts, interstratified with thick beds of red marl and sandstone, as also with white chalky marl.

The compact white limestone, with its associated beds, constitutes the main or middle part of the formation, and contains organic remains, generally casts: beneath these limestones there are beds of sands and marls, the latter containing fibrous gypsum, and being often associated with bluish gray compact limestones, sometimes traversed by veins of calcareous spar.

In this lower part of the formation there are beds of yellowish white limestone, which are more earthy than the others, and contain a greater abundance of organic remains, among which a gigantic cerithium may be noticed, together with echinites, spines of echinites, ostreæ, &c. Some beds are principally composed of the remains of broken shells.

The upper beds of this formation are generally chalky, sandy and marly: still however many beds are very compact, and in general texture and appear-

ance agree with those of the central portion. This upper part contains the fossil remains of the genera Conus, Cerithium, Astarte, Natica, &c.; and near the sea coast in the parishes of St. Thomas-in-the-East, Portland, St. George, and St. Mary, a considerable quantity of corals, which frequently have almost a recent appearance.

The following is a list of the fossil organic remains which I procured from the white limestone formation of Jamaica:

Multilocular Univalves.

1. Nautilus.
2. Nummulites.

Univalves.

3. Serpula.
4. Conus.
5. Buccinum.
6. Pleurotoma.
7. Cerithium (two species).
8. Turbo.
9. Natica.

Bivalves.

10. Mya.
11. Astarte.
12. Cardita (two species).
13. Arca.
14. Pecten (two species).
15. Ostrea.
16. Anomia (Lamarck).
17. Terebratula.

Echinites.

18. Spatangus.
19. Cidaris.
20. Large and small spines of Echinites.

Corals.

21. Cellepora.
22. Astrea.*

The cerithium figured in Plate XXI. is of considerable size; yet it will be observed, that, when perfect, it must have been much larger. At one time, I considered that it might have been a cast of a shell analogous to cerithium giganteum; the latter is however a much taller shell than the one under consideration, which, in general outline, more resembles the C. Cornucopiæ of Sowerby (Plate CLXXXVIII.). Being only a cast, it is, of course, very difficult to refer our fossil to any particular species, and it is very probably a new one:

* For the determination of those of the above which occur only as casts, I have to acknowledge myself indebted to Mr. Miller, author of the "Natural History of the Crinoidea."

for although we are generally prepared to meet with the same fossils in rocks of an older date,—such for instance as the submedial or transition limestones,—yet in rocks of the tertiary class, which are generally considered as of partial occurrence, and more regulated by local circumstances, we scarcely expect to meet with fossils of the same *species* at any great distances, such for instance as that between Paris and Jamaica. Let however the above list of organic remains be compared with that given of those contained in the London Clay by Messrs. Conybeare and Phillips in their "Outlines of the Geology of England and Wales," and with the fossils contained in the *Calcaire grossier* of Paris enumerated by MM. Cuvier and Brongniart in their account of the beds of the Paris Basin, and the reader cannot fail to be struck with the general resemblance between them as far as respects fossil *genera*. From this circumstance it might be inferred, that the white limestone of Jamaica belongs to the same epoch of formation as the *Calcaire grossier* of Paris and the London Clay of England.

This formation is of considerable depth in several places, particularly in the parishes of Manchester, Clarendon, St. Ann, St. Thomas-in-the-Vale, and St. David; its thickness in some of these places cannot be less than from 2000 to 3000 feet.

In enumerating the localities of this formation, I shall begin with the parish of Manchester; because that parish forms the south-western portion of the part of Jamaica which I propose to describe, and moreover the middle of the formation can be well studied among its mountains.

The road from Mount Pleasant in Clarendon, over the mountains to New Forest near Alligator Pond Bay, presents a great mixture of the compact white limestone with a red sandstone: the latter seldom appears on the surface in an undecomposed state, its place being very generally marked by a red marly soil. The mass of these rocks has a southerly dip, where the dense vegetation will permit an examination. On the descent of Plowden Hill towards New Forest, compact white limestone is seen interstratified with rather compact red sandstone, which contains nodules and stripes of the white limestone, evidently of contemporaneous formation with it. The beds are slightly curved, and dip sometimes at 35°, at others at 40° to the S.W.

The neighbourhood of New Forest, near Alligator Pond Bay, presents singular mixtures of the white limestone with the red sandstone: the most remarkable of these are found among the Plains (as they are called) of St. Elizabeth's, included between the Santa Cruz Mountains and those of Manchester, and terminating near Alligator Pond Bay. Small patches of rock, rising from ten to twenty feet above the level of the plain, are abundantly scattered over

its surface, presenting at some distance the appearance of numerous clumps of trees, distributed over an immense park. These rocky patches are composed of compact white limestone, and the rest of the plain principally of red sandstone; thus giving to the former the appearance of the remains of continuous strata, the greater part of which has been swept away. This would in some measure seem the case; for although the lower limestone strata of these rocky patches are often much intermingled with the red sandstone, and are evidently of contemporaneous formation with it, still the upper strata terminate so suddenly, that there is some reason for believing that they once extended to a much greater distance than they do at present: thus making it probable that the patches formed continuous strata which have in a great measure been destroyed by denudation, in the same manner as is shown by the larger masses of rock found isolated in other parts of the world.

These patches may also be accounted for by supposing the white limestone patches to have been included among the red sandstone strata, in the same manner as smaller portions are now seen in the same neighbourhood; so that when the plains were formed into their present state, the red sandstone, which was softer than the limestone, may be supposed to have given way before the causes which have produced most of the present inequalities in the earth's surface, while the limestone was left. I observed that the white limestone beds of many of these patches had a slight dip to the S.W.

The intimate mixture of red sandstone and white limestone in the neighbourhood of New Forest occurs frequently in the same strata, and in such a manner as would make it most difficult to be accounted for except by the theory of contemporaneous formation. There are however other mixtures of the two substances which must have had a different origin, such as the breccias and conglomerates in the same district. These are composed of either fragments or rounded pieces of white limestone, but principally of the latter, cemented by red sandstone, or an arenaceous substance of a lighter colour, approaching to yellowish brown, and presenting much the same appearance as the cementing matter of some magnesian or dolomitic conglomerates. It does not however contain any magnesia; for Dr. Daubeny*, to whom I gave specimens for examination, states that "not one of them contains any appreciable quantity of magnesia." The pieces of white limestone are so much rounded in the conglomerate, that they appear to have been derived from the forcible destruction of some of the beds by water, anterior to the formation of a considerable portion of the Jamaica white limestone. The red arenaceous

* Professor of Chemistry at Oxford.

rock mixed with the limestone near New Forest, is in a great measure calcareous. The white limestone of this place varies in its degree of hardness, but is principally compact; in one instance I observed it of a crystalline structure with thin spathose divisions.

Quitting the Plain or Savannah above-mentioned, and ascending Marlbro' Hill, white limestone will be seen dipping to the S.W. The May Day Hills are composed of a mixture of white limestone, red sandstone, and white marls, which are continued down the beautiful valley with the inharmonious name of Mile Gully, a name moreover altogether inappropriate as applied to this valley, which is many miles long, and any thing but a gully. The general dip of the whole limestone formation of Manchester appears to be at various angles to the S.W.

The Round Hill in Vere is formed of a continuation of the Manchester white limestones, and is remarkable for the warm saline spring that rises out of the limestone near its base, at the place called the Bath*. The white limestone formation would indeed seem in some measure saliferous, for salt is found in the Long Mountain near Kingston, produced apparently by the evaporation of saline dippings from the rock†. Among the limestones of the Bath in Vere, is one of a roseate flesh-colour, which might be made useful for ornamental purposes.

The Mocho Mountains in Clarendon are composed of the same rocks as those of Manchester, the red sandstone being much more scarce. The stratification of the Mocho Mountain limestones is in general difficult to determine, from the thickness of the forests by which they are covered, and from the decomposed surface of the beds, which are often honey-combed to a considerable depth.

The traverse over these mountains by the Rock road exposes a considerable quantity of compact white limestone, the beds of which would seem to vary from 3 to 20 feet in thickness; for I observed blocks that must have belonged to rocks of at least the latter size. Between the higher part of the road and Four Paths estate, white marls come in, and are succeeded by a yellowish and rather arenaceous rock effervescing with acids. The glen through which the road winds to Halse Hall Crawle presents cliffs in which the white limestones appear to dip to the Southward at about an angle of 15°. In two or three places on the ascent, red sandstone will be observed interstratified

* I found the temperature of this water = 92° Fahrenheit.

† I was informed that the spring at Port Henderson was saline, and that it rose from white limestones.

with the white limestone; and at the Crawle itself I found casts of univalves and bivalves in the limestone.

We find the lower beds of this formation in the neighbourhood of Chapelton, (Clarendon,) between which place and Four Paths estate above-mentioned, the road exposes white marl, which is followed by whitish friable sand mixed with gray, and a little red, marl: these beds dip to the N.N.E. at about 45°. At Chapelton a whitish calcareous marl contains portions of yellowish limestone full of broken fossil shells, some of which may be easily recognised as of the Ostrea genus. Among these rocks I found specimens of the large Cerithium formerly mentioned. Lower down the hill upon which Chapelton stands, white limestones mixed with white marls and sands, some of which are red, continue to where the whole formation seems to rest upon porphyritic conglomerate. On the road to Savoy estate, a reddish and white small-grained conglomerate, the pebbles in which are mostly porphyritic, rests upon the other, and may either belong to the lower part of the white limestone formation or the upper portion of the porphyritic conglomerate.

The Barquadier road from Chapelton to the plains of Clarendon shows that the limestones of that part of the Mocho Mountains dip at the first part of the descent at an angle of 15° to the E. by S., and further down at about 20° to the S.E. These limestones are continued to Lime Savannah, between which place and Denbigh estate, in a woody part of the road not far from the former, a small-grained conglomerate is interstratified with them, the pebbles of which are principally quartzose.

The white limestone formation is continued from the Mocho Mountains across the Rio Minho, and forms the mountains on the left bank of the river, which gradually fall into the low hills which separate the plains of Clarendon and Vere from that of St. Dorothy's, and are continued to the sea in Old Harbour Bay. These low hills are also composed of the same formation, exhibiting a mixture of compact white limestone, and white and red marls; the latter being frequently traversed in different directions by white calcareous matter. In the rising behind Halse Hall House (Clarendon), which forms a part of these low hills, white marl rests upon compact white limestone, among which there is a breccia, composed of fragments of compact white limestone cemented by a yellowish-brown arenaceous and calcareous substance. In the white limestone behind Halse Hall House I found a Nautilus, Terebratulæ, and Nummulites, with numerous casts of the genera Arca, Astarte, Cardita, Cerithium, &c., and abundant casts of Astreæ. The beds dip to the W.S.W. at about 20°.

Kemp's Hill, which rises out of the diluvial plain of Vere, is formed of

white limestone, as is also the hill named Portland Ridge, the most southern part of Vere and of Jamaica; the connexion of these hills with the white limestones of Manchester, Clarendon and Vere, is concealed, and covered up by diluvial and alluvial plains.

The formation under consideration is continued from Clarendon into St. Dorothy's and St. John's, forming a considerable portion of the mountains in the latter parish. At Wood Hall estate (in the former parish) it is found close to the trap, upon which it seems to rest, and from which it is separated by marl beds: from hence to the southward, the hills are composed of compact white limestone mixed with red sandstone and white marl. The dip observable on the road to Old Harbour varies, and shows that the strata undulate; the most prevalent is, however, to the southward, away from the trap. The small hill upon which the Rectory stands, near Old Harbour, is composed of white limestone.

Proceeding from the latter place to the Rectory of St. John's, we find the white limestone at Spring Garden Hill dipping at about an angle of 20° to the S.W. At Hollow Rock Hill it is mixed with red sandstone, and from thence to St. John's Rectory it is associated with red sandstone, and red marl traversed by numerous veins of whitish calcareous matter, the two latter rocks predominating. The compact white limestone is more abundant between St. John's Rectory and Mountain River estate, where it meets the trap: patches of it are however seen near the Barracks, after which it appears in considerable force on the descent into Luidas Vale: among the beds in the latter situation, there are some resembling those of Chapelton, principally composed of broken shells; these beds are also mixed with marls, and dip at about 45° to the S. The white limestone formation seems here much confused; in one place it dips slightly to the northward, and in another at from 10° to 15° to the S.W., so that it would be difficult from this section to say whether the limestone rests upon the trap or the latter forms a dyke amid the former.

By reference to the map, it will be seen that the limestone formation occurring in Manchester, Clarendon, Vere, and St. Dorothy, winds round the eastern extremity of the trappean district which separates the above-mentioned limestones from those of St. Ann's, &c. for a considerable distance: thus the white limestone on the north of St. John's becomes connected with that on the S.

Although it may seem out of place to notice fine scenery amid a dry detail of Geological facts, yet that traveller must be indeed dead to the beauties of Nature, who would not be struck with the fine and picturesque effect produced by the first burst of Luidas Vale, in his descent from the Barracks. This beau-

tiful spot would be a lake but for the subterraneous channels the waters find for themselves: it is on every side surrounded by mountains, broken into a series of fine forms, and covered with forests, while the bottom of the Vale presents a mixture of buildings and cane-fields, the brilliant green of the latter contrasting finely with the other colours. The scenery of Jamaica is generally fine, varying from the beautiful to the grand, and such as can only be seen in the tropics; for there alone is found that vegetation, which gives such a peculiar character to the landscape.

The hills and mountains surrounding Luidas Vale are composed of white limestone, the strata of which have various dips: among the small hills on the north, the dip is gently to the S.E., while it will be found to the N. by E. at an angle of from 45° to 50° among the mountains that bound the Vale on the south, where the limestone joins the trap near Pleasant Hill. The same kind of limestones appear from beneath diluvium near Worthy Park estate, which is situated nearly in the centre of the Vale.

The principal subterraneous water passage of Luidas Vale is to the east of Thetford estate, where the river flows beneath a high mountain and re-appears on the other side of it, giving rise to the Black River (as it is denominated in Robertson's Maps) in St. Thomas-in-the-Vale. The waters lose themselves in many places in this vale, among others close to the works of Worthy Park, where the water, brought from a considerable distance, turns the great wheel and is swallowed up close to it.

It may here be remarked, that the white limestone formation of Jamaica is characterized by being hollowed into innumerable holes and caverns, among which the waters, which fall in the districts composed of it, are lost: hence arises the general scarcity of springs in that part of Jamaica principally composed of these rocks, and the necessity the inhabitants of such parts are under of making tanks to preserve a supply of water. The portions of country occupied by the white limestone formation are in a great measure shown upon a good map of Jamaica (Robertson's small map for instance) by a great want of rivers, while the latter are numerous in the districts composed of other rocks. Some rivers will be found to flow for a short distance and then sink, sometimes coming again to the surface and again sinking: several springs flow only for a very short space, being received into some cavity.

The white limestone of Luidas Vale is continued into the large parish of St. Ann, which seems almost wholly composed of rocks of this formation, presenting there a mixture of compact white limestones, earthy limestones, white marls, and beds of red sandstone. Many large casts of bivalves are found in this formation about a mile and a half from Green Park on the road to the

Moneague. This parish affords many good sections, among which may be mentioned the cliffs between Ocho Rios Bay and the Roaring River *.

The St. Ann's limestone is continued into St. Mary's and St. Thomas-in-the-Vale; the space that it occupies will be best seen by reference to the map. In the former parish, besides the component parts of this formation which have been above enumerated, the shores present us with a rock composed of either white or flesh-coloured limestone, mixed with marl and containing an abundance of corals intermingled with shells; the former when broken having almost the appearance of recent specimens. I could not perceive that these beds were separated in any marked manner from the other white limestones, which they resemble in mineralogical composition: on the contrary, they seem to pass into them, and to form the upper part of the great white limestone formation of Jamaica.

These beds are observable on the coast in the vicinity of Ora Cabessa Bay, and constitute the point upon which Fort Haldane stands, the island opposite Port Maria, Pagee Point, and several small patches on the coast from the latter place to Forster's Cove, where the points on both sides are formed of them. They here dip at about 25° or 30° to the N., and are separated from the grauwacke by thick conglomerate beds, which also have the same dip: on the road up to a house on the western side of the cove, the corals are beautifully exposed. These beds are also found at Blowing Point, Don Christopher's Point, and in the vicinity of Jack's Bay: at the former places they are generally white and compact, sometimes of a flesh-colour, and do not contain so many corals as at the latter place, where the limestone forms a rising ground some little distance into the interior.

Between Palmetto Grove (St. Mary's) and Pimento Grove, and to the north of the trap rocks of the latter place, the lower marls of the white limestone formation are seen, containing some beds of compact grayish blue limestone. The high hill between Palmetto Grove and Tremolesworth also exposes the lower members of this formation, in which the marls are abundant. The continuation of this hill running to the N.W. appears formed of the same rocks.

* The falls of this river are extremely beautiful. The quantity of water must sometimes be considerable, and is most probably collected in the high lands by numerous sink-holes, which afterwards unite in one cavity, through which the waters find their way to the surface at a lower level. After taking a considerable leap over a face of rock the river rushes through woods, and becomes divided into many branches producing a singular effect as they form cascades among the trees, which even in some places rise out of the channel itself, without being overthrown by the force of the water: this would seem in some measure attributable to the quantity of carbonate of lime that the waters deposit upon the roots and fallen pieces, which are thus firmly cemented together.

Proceeding with the continuation of this formation into St. Thomas-in-the-Vale, we find the lower marls, which are sometimes schistose, in the vicinity of Pimento Grove, and on the southern side of the trap in that district: from hence to Rio Magno Pen the limestone will be observed in great abundance.

The hills on either side of Williamsfield and Sandy Gully estates, are formed of compact white limestone resting upon trap rocks; the strata, as before remarked, appearing to have been once continuous, and the whole looking like a valley of denudation.

The mountains that surround the great basin of St. Thomas-in-the-Vale are almost all composed of the white limestone formation; and the basin itself would seem convertible into a large lake, if the ravine through which the Rio Cobre flows, called the Walks' Road, between the Bog Walk and Spanish Town, were stopped up.

Upon Mount Olive estate in this parish there is a singular natural bridge, formed of compact white limestone. A small river, flowing in a precipitous ravine, is crossed by a natural arch, beneath which it runs (see Plate XX.). This natural bridge is lofty, and of sufficient breadth at the top to permit a cart-road over it, which has accordingly been established. If it were not for the arch, the water would be blocked up by this natural wall or barrier, the cliffs rising high and precipitous on either side, and preventing its escape laterally. The cavernous nature of this limestone is curiously shown on the same property, by the manner in which the water is procured to turn the water-wheel. A rivulet runs on the side of the hill opposite to that on which the works are placed; and to obtain water for the mill, the rivulet is dammed up at a given place, when it finds its way through the hill, rushes out of a hole near the works, and turns the wheel.

The Walks' Road ravine exposes a good section of compact white limestone and white marl beds; the former are seen varying in thickness, and dipping to the S.W. or S.S.W., near the opening of the defile into the basin of St. Thomas-in-the-Vale.

The formation under consideration forms the mountains on the north of the diluvial and alluvial plain of St. Catherine's, and constitutes small hills rising out of it, close to Spanish Town, and on the road to Kingston. A white chalky marl is exposed on the same road between the former place and the Ferry. The Healthshire Hills, and the hill that rises above Port Henderson (opposite Port Royal) are also composed of the same rocks.

The mountains which join the elevated land of Stony Hill with those of St. Catherine's, and which bound the plain of Liguanea for a considerable distance on the north, belong to this formation. On the southern ascent to

Stony Hill, compact white limestone, in some places associated with red sandstone, dips to the S.S.E. On the lower part of the descent from the same hill to the Agua Alta, light coloured marls and sands separate the great body of this formation from the porphyritic conglomerate on which it rests.

The white limestone is continued but a short distance eastward from Stony Hill: I have however observed a small portion of it resting upon syenite near Somerset estate.

The Long Mountain situated to the N.E. of Kingston rises principally from beneath diluvial gravel, and is wholly formed of white limestone: the dip is difficult to trace, yet markings may here and there be observed, which would seem to make it probable that it is to the S.W. The most remarkable thing in this mountain is the salt, procured above a pen belonging to Mrs. Clark, sometimes in sufficient quantities to be used at table; it is found in a small recess, and appears to be derived from the evaporation of saline water which percolates through the marly limestone of the place.

From the Long Mountain this formation is continued into those of the Port Royal Mountains which approach the sea, and a good section is afforded of its beds up the valley of the Cane River to the Cascade. The white limestone is at first observed at the latter place in rather thin beds dipping to the N.E. at a highly inclined angle. Higher up the valley, the beds become thicker and dip to the S.W. at from 75° to 80°: near the falls the beds are almost perpendicular. From the various inclinations of the strata, they appear to have been much disturbed in this vicinity.

From the valley of the Cane River, a belt of the white limestone formation, varying in breadth, and separating the older rocks of the interior from the sea, runs round the coast from the South to the North side of the island by the East End, and passes through the parishes of St. David, St. Thomas-in-the-East, Portland, and St. George's.

The lower part of the valley of the Yallahs River presents a good section of the St. David's portion. Ascending the river from Albion estate, compact white limestone beds are seen near Norris dipping to S.S.E. at about 40°; they will also be observed curved on the face of the cliffs, which for some distance up are formed of this rock on both sides the river. Approaching Mount Sinai estate, the lower beds of the formation are exhibited by the road side, and in a great measure correspond with those occurring near Chapelton (Clarendon), with the exception that the sands do not seem so abundant, whereas the marls are more so. Among the lower white limestone beds, which are slightly earthy and arenaceous, I found many organic remains, among them echinites (cidaris and spatangus), spines of echinites, ostreæ, myæ, and

cerithia; of the latter genus, besides a smaller species, I met with the gigantic one figured in Plate XXI. and which is also found in a similar situation at Chapelton. Beneath these beds there is a succession of gray and light coloured marls, among which I discovered fibrous gypsum, and thick beds of compact gray blue limestone; the whole resting upon porphyritic conglomerate near Mount Sinai.

White limestone beds, from one foot to three feet in thickness, have a curved dip to the S.S.E., between Norris and Lloyds upon Vavasers River. Marl, limestone, and slaty beds of the lower part of this formation are seen from the latter place up the valley of the Back River to the ridge that descends from Yallahs Hill*, and separates St. David's from St. Thomas-in-the-East. This connecting ridge, or *col* as it would be called in Savoy or the French Alps, occurs between the Petersfield and Back rivers, and presents a mixture of white marl, brown sandstone, slate clay, and gray marl, with gray and white limestones, in beds nearly vertical, having a direction about N.E. and S.W. Yellowish sandstone should also be added to this list.

The white limestone formation of St. Thomas-in-the-East comes close up to the submedial country between Spring Garden and Bath; and, between the former place and Whitehall estate, upon the Plantain Garden River, white limestone associated with red marly sandstone rests upon argillaceous slate. The low hills on the south of Plantain Garden River between Whitehall and Sunning Hill are composed of white sandstone and marl mixed with reddish sandstone. Beds of gravel and coarse sandstone are found near Golden Valley, the relations of which to the rocks of the surrounding country I did not clearly ascertain, but they seem to occur beneath the white limestone formation.

The low hills extending to the sea on the south of Bath are composed of the white chalky marl portion of this formation, and might easily be mistaken for some varieties of chalk. These hills, which reach to the Great Morass near Morant Point, are separated from the white limestone on the north of Plantain Garden River by the diluvial and alluvial plain (rich in sugar estates) which extends from the mouth of the river to beyond Bath, and most probably conceals the junction of the limestone on the south with that on the north.

The white limestone that forms the coast from the north of Wheelersfield, Hordleys, Amity Hall, and Holland estates round the North-east Point to Port Antonio, presents an association of compact white limestone and white marl, mixed occasionally with some red. At Manchioneal Harbour the white

* This mountain is stated to be 2706 feet above the sea in Robertson's Map.

marl contains corals, spines of Echinites, and Terebratulæ, besides casts of other shells. Throughout the whole of this coast the white marl is the predominating member of the formation; and most of the low points, which are numerous, contain an abundance of corals, which have almost a recent appearance when fractured, resembling those formerly mentioned as occurring at Forster's Cove (St. Mary's). The dip of this limestone and marl is either E., N.E., or N.N.E., according to its bearing with the interior of this part of the island round which it mantles.

On the eastern side of Turtle Crawle Bay a sandy and chalky rock is worked for building-stones, which are used at Port Antonio; the white limestones and marls of which latter place rest upon porphyry.

From Port Antonio to Burlington (near the mouth of the Rio Grande) the coast is formed of white limestone and marl, the latter being sometimes sandy; the beds of the former dipping northerly at the cliffs near the ford over the Rio Grande.

Good sections are afforded of this formation in St. George's by the Swift, Great Spanish, and Buff Bay rivers. It extends up the former to Eden estate; and both sides of the river present fine cliffs of the rocks under consideration. The white limestones extend up the Great Spanish River to about half a mile or more above Skibo, the beds varying in thickness, and being contorted near the latter place. The road from Canewood to Low Layton estate, between the mouths of the Swift and Great Spanish rivers, is upon white sandy marl and limestone; but to the northward of Lennox, and rising above Low Layton the country is composed of volcanic rocks.

This formation continues up the Buff Bay River for about a mile above Charles Town, the beds varying in thickness and dipping northerly, being however curved in some places. The hills that back the low flat, between Annotto Bay and Buff Bay are composed of white limestones and marls; the extent of country occupied by them between the sea and the older rocks gradually becoming narrower as we approach the former place. In one spot between these two villages, I found nodules of chert in the white marl, from which circumstance it appears probable that the loose pieces of chert scattered over the surface in some parts of St. Mary's parish, as for instance in the neighbourhood of Islington estate, and in the diluvial soil between Unity and Non-Such estates and Port Maria, may have been derived from the destruction of some beds of the white limestone formation: and this supposition is rendered more probable by finding pieces of compact white limestone scattered over the surface of the submedial or transition country between Non-Such estate and Port Maria.

Savannah Conglomerate and Sandstone.

Next in order to the white limestone formation may be mentioned a sandstone and a conglomerate that rest upon it, and which I have named as above because I have most frequently seen them among Savannahs. These rocks will be found at the base of the Mocho Mountains (Clarendon), forming the commencement of the large plain of Lower Clarendon and Vere; St. Jago's Savannah, extending to these mountains, is principally composed of the sandstone, which is light coloured and friable. From hence the sandstone and conglomerate sweep round by Burnt Savannah to Halse Hall and Hays Savannahs, skirting the white limestone hills and separating them from Diluvium and Alluvium.

At Halse Hall the conglomerate is composed of rounded pieces of various porphyries and trap rocks, cemented by a dirty white argillaceous substance, and mixed with carnelians, agates, chalcedonies, onyxes, and jaspers. The latter minerals are by no means rare in the conglomerate hill to the south of Halse Hall works (Clarendon).

In the water-courses among the above-mentioned savannahs there is an abundance of magnetic iron sand: this mineral is indeed common in several parts of Jamaica, but not so much so, I think, as among the savannah sandstones and conglomerates *.

The same sandstones and conglomerates will be observed resting upon the white limestone formation in several places on the road from Halse Hall to Old Harbour. These rocks occur in other parts of Jamaica, but in no great abundance in that portion which I have selected for description.

Diluvium and Alluvium.

It is gratifying to find Professor Buckland's distinctions so well borne out in a country far removed from those places where they were originally made; and to see that the same cause, which broke up the surface of European countries, reducing its harder portions into gravel, has also affected Jamaica in a similar manner. The divisions into Diluvium and Alluvium are too well known to require any notice here: I shall therefore proceed to describe those places in Jamaica, where I have observed them.

The first district which I shall notice is the great plain of Liguanea, upon

* The beach at the mouth of the Rio Minho (on the left bank) is almost wholly composed of magnetic iron sand, as is also that at the base of the Round Hill in Vere: the same sand is abundant on the coast between the Rio Grande and Swift River (north side of the island), and it is frequently found in the water-courses of the Jamaica lowlands; it is not however confined to them, as I have met with it in the mountains.

the lower part of which Kingston is situated. This plain presents an inclined surface, falling gradually from a height of about 700 feet, which it attains where it abuts against the mountains that bound it on the north. It is almost wholly composed of diluvial gravel, consisting principally of the detritus of the St. Andrew's and Port Royal mountains, and evidently produced by causes not now in action, but derived from those mountains in the same manner and probably at the same period with the numerous tracts of European gravel which have resulted from the partial destruction of European rocks. The mountains which bound this plain are composed of white limestone, porphyry, syenite, greenstone, red porphyritic conglomerate, and siliceous sandstones, with red sandstones and conglomerates of an older date. Rounded pieces of all these rocks, those of the first being, however, very rare, form the diluvial gravel of Liguanea, which has resulted from their partial destruction. Though the pebbles are not in general of great size, there are some large blocks of siliceous sandstone among them near the Hope estate, and I have seen boulders of greenstone near the base of the Long Mountain.

The Hope River, with the Mammee River which falls into it, drains a considerable portion of the St. Andrew's Mountains, and loses itself, when the waters are low, among the Liguanea gravels, where the latter meet the solid strata of the mountains; but when swollen by heavy tropical rains, the river rushes with considerable force through the defile near the Hope Tavern, and traverses the gravel plain, which it has cut to a considerable depth: so that in fact the causes now in action tend to destroy the diluvial gravel plain of Liguanea rather than add to it. The section of these gravels, which the river has formed by cutting its bed, cannot be less than from 200 to 300 feet in depth near the Hope Tavern *.

Proceeding up the Hope Valley, a part of the road displays a portion of diluvium (the rounded pieces of rock in which are large) resting upon a projecting portion or shoulder of the mountain, which rises high above the river.

In addition to the Hope River, numerous gullies formed by heavy tropical rains cut the diluvial plain of Liguanea in various directions, so that every stream that traverses it, tends to destroy it.

This plain descending gradually into the sea, and being in a great measure defended from the ravages of the latter by the Palisades (a sand-bank that extends several miles, and joins the town of Port Royal with the main land), alluvial matter is deposited in some parts of the shore, more particularly

* The Tavern itself is 698 feet above the level of the sea according to my barometrical observations, and the diluvial gravel rises above it.

between Kingston and Port Henderson, where mangrove trees are numerous. These trees are particularly well calculated for the formation of alluvium, their long stilt-like roots collecting mud and other matters together, and protecting what they have accumulated from any sudden rush of water.

The diluvial plain of Liguanea is continued westward through the lowlands of St. Catherine's and St. Dorothy's; sands and clays are more abundant in these districts, but in other respects the diluvium is the same. The sections afforded by the rivers and gullies are of considerable interest, though there is no one so deep as that of the Hope River.

Bones of the elephant, rhinoceros, &c. have certainly not yet been discovered in the Jamaica gravels: but it should be recollected that the opportunities for such discoveries are by no means so common as in those countries where gravel is extensively used for roads, &c. The climate, moreover, is such that few feel tempted to risk their health by prosecuting researches of this nature. The large plain of Vere and Lower Clarendon is separated from the above by the low range of white limestone hills formerly mentioned. It is surrounded by white limestone hills and mountains on all sides save on the south and south-east, where it is washed by the sea, with the exception of that portion protected by Portland Ridge. The greater part of this plain is diluvial, consisting of gravels, clays, and sands; the former are principally composed of porphyry, greenstone, and other trap rock pebbles, that would appear to have been in a great measure derived from the partial destruction of the trap districts among the St. John's and Clarendon mountains.

Many good sections are afforded of this diluvium by the Rio Minho, which traverses it nearly through its whole length, as also by many deep gullies; it is easy to remark here, as in Liguanea, that the causes now in action tend to destroy this plain, and are altogether inadequate to its formation.

It is remarkable, that, though the diluvium of this district is nearly surrounded by white limestone hills and mountains, very few fragments of this rock are found in it; from which circumstance it would appear that the limestones, though in general tolerably compact, were unable to resist the effects of violent attrition so well as the greenstones, porphyries, &c. The Vere and Clarendon diluvium rests for some distance upon the Savannah sandstones and conglomerates before mentioned, and it is often very difficult to distinguish between them.

Diluvium occurs at the bottom of Luidas Vale, and in some parts of St. Thomas-in-the-Vale; and, mixed with alluvium, it forms a considerable tract of low land between Annotto and Buff bays. As might be expected the mouths of the rivers are alluvial, but some of the country about Welsh Wo-

man's Point, and Whydah Bay, between the Rio Grande and Daniel's River (Portland), appears to be diluvial, as may also be part of the gravels occurring in the plain from Bath (St. Thomas-in-the-East) to the sea. Through this plain the Plantain Garden River flows. Most of the gravels in the neighbourhood of Serge Island estate (St. Thomas-in-the-East) seem also to belong to the same epoch of formation.

As connected with the subject, it may be as well to notice the valleys of the white limestone formation, which completely oppose themselves to the theory that valleys have been formed by the waters now flowing in them; for no waters flow in the greater part of those hollowed out of this formation, the limestone being, as before mentioned, extremely cavernous, and the rains that fall being speedily swallowed up in it: yet these valleys are, as to form, like most other valleys, and probably owe their origin to the same causes which have produced the greater part of those in the chalk, oolites, &c. of England, at the period when diluvial gravel was formed.

In Jamaica, where so many caverns exist, ample opportunities are without doubt afforded of seeing whether or not they contain the remains of animals that existed before the diluvial or great gravel period. Of the larger caverns I only visited two, one in Luidas Vale, and the other in Portland Ridge (Vere).

The first is situated near Swansea estate, and winds considerably; the bottom is in some places formed of clay, but I have not heard that any bones have ever been found in it*. The second, or Portland Cave, reminded me of Professor Buckland's cave sections in one place, where a crust of stalagmite covers silty clay; but whether or not the latter contains bones I could not ascertain, from the want of the necessary implements. How far this stalagmitic crust

* The entrance to this cavern is highly picturesque, and is concealed from a distant observer by dense tropical vegetation. The first part of the cave varies in height, and is, in some places, lofty; this portion is covered with grotesque stalactites and stalagmites, and some of the columns are very beautiful. It terminates in a small open space surrounded by cliffs, where some negroes cultivate plantains and cocos. The length of the first cavern is about 76 paces allowing for all inequalities. After crossing the small open space above mentioned, (probably only a portion of the cave that has fallen in,) we entered a cavern forming a winding chamber, about 89 paces in length, the sides, roof, and floor of which are covered with stalactites and stalagmites. We then crept through a low communication about three paces long, and entered another chamber about 34 paces in length, containing grotesque stalactites and stalagmites. We then came to a small space, through which we crept upon our hands and knees, for about the distance of two paces; and this opened into a lofty cavern 54 paces in length, where bats were clustered in considerable numbers on a portion of the roof. This chamber was separated from another by a small division. The space now entered was tolerably lofty and about 21 paces long: at the end, the roof had fallen in, and

(which is of some thickness) formerly extended, it would be difficult to say; hundreds of people having visited this cavern, as their names, scrawled upon the wall with charcoal, testify, and the floor in consequence, as may be reasonably inferred, not presenting the same appearance as when the cavern was first entered. The cave is situated on the side of a hill, within a short distance from the sea; but it is sufficiently elevated to prevent the possibility of the clay having been derived from the sea at its present level*.

Volcanic Rocks.

In that part of Jamaica which I examined, I observed rocks of this character only at the Black Hill, which is situated between Lennox, Low Layton, and the sea (St. George's). This hill, when viewed from the neighbourhood of Buff Bay, has a somewhat conical appearance, and rises above the low hills that extend towards Savannah Point: the hill, however, when approached is seen to be no cone, notwithstanding its effect at a distance.

The rock, of which the Black Hill is principally composed, is grayish brown and hard, gives out an earthy smell when breathed on, and may in general terms be described as a volcanic amygdaloid, the cells, with which it

admitted the light of day; and the rubbish formed a rough ascent and descent, occupying about 60 paces of the cavern's length. We then entered a chamber 14 paces long, which is succeeded by a low passage, where we could not stand upright, 21 paces in length. After passing this low place, we found ourselves in a chamber 14 paces long, and we then entered a low place where the bed of limestone that formed the roof gradually approached the clay floor and prevented further progress.

Near this cavern is another, from which the people on Swansea estate obtain their supply of water, which remains at a greater or less depth in it according to the seasons. Sometimes, when heavy rains have fallen in certain parts of the neighbourhood, with which it must have communication, it rushes out of the cavern with great noise and impetuosity into a gully, but is soon swallowed up among the sink-holes.

* The entrance into Portland Cave is easy, and, from being low, not very striking; but when we had entered a short distance a fine chamber presented itself, ornamented with several very beautiful stalactitic columns. We then proceeded to another branch of considerably larger dimensions than the first. This portion is extremely beautiful, the stalactites are well arranged for effect, and the whole had a fine appearance when the negroes with torches were properly distributed among the columns, many of which are of large dimensions, and beautifully crystallized on the surface. After examining this chamber, which is of considerable length, we retraced our steps for some distance, and then branched off through passages, in two or three places rather low, into a lofty and winding chamber of some length, which did not however possess the beauty of the first: at the end we crawled through a low passage upon our hands and knees, and entered a small chamber that communicated with the surface. We found the heat in this cavern very great, probably arising from its being near the surface.

abounds, being mostly filled: those, however, which have been exposed to the weather are frequently empty, as are also those within a few inches from the surface. The interior of the empty cells is often incrusted with a little oxyd of iron, while those that are full, and convert the rock into an amygdaloid, contain chalcedony, carbonate of lime, and occasionally some of the zeolitic minerals: in general, chalcedony lines the cavity, and the central part is composed of carbonate of lime. This rock, when the cells are empty, has a very lava-like appearance, and the greater part of it which is exposed is arranged in concretions reminding the observer of the porphyry at Pimento Grove. These concretions are separated from each other by a white argillaceous substance, which is in considerable abundance in one or two places. On ascending the hill it becomes more rare, or at least is not so easily seen as on the coast, where cliffs of volcanic amygdaloid rise above the sea.

Near the summit of the Black Hill I found the rock changed in several places into a substance between obsidian and pumice, having however more the character of the latter than of the former, and presenting every appearance of having been subjected to the action of fire at no very distant period (geologically speaking). I also found some pieces of rock, changed on the surface into this kind of obsidian-pumice, which in the interior were claystone porphyries, having a dark coloured base with white crystals of felspar.

The connexion of this hill with the sandy marl member of the white limestone formation, which surrounds it on all sides but that of the sea, is very obscure: some gravel beds will however be observed close to it, as it is approached from the mouth of the Swift River.

The Black Hill would seem referrible to what are commonly called extinct volcanos. How many more of them there may be in Jamaica, I had no means of ascertaining, though probably others may exist, more particularly in the western portion of the island, respecting the geology of which I could obtain little or no information, except that the white limestone is very common.

Explanation of the Sections. (Plate XIX.)

In the preceding pages I have given little more than a detailed account of the composition of the Jamaica rocks, and the extent of country occupied by them, touching but slightly on the sections which show their relative positions, conceiving that these would be better thrown together, after the composition of the formations had been described.

Commencing then with the section from Kingston over St. George's Gap to Buff Bay (Plate XIX. fig. 1.), we find the Liguanea diluvium forming an

inclined plane from Kingston to the base of the mountains on the north of Somerset estate, where a few patches of compact white limestone separate it from the syenite.

Ascending towards St. George's Gap, the lower mountains are found to be formed of syenite for some distance; to this succeeds a conglomerate composed of porphyry and other trap rock pebbles, having a brownish red argillaceous cement, and occurring in beds of various thickness. The dip being southerly, the conglomerate has the appearance of supporting the syenite. In one or two places I observed greenstone associated with the conglomerate: and beneath the latter there is a light coloured sandstone, similar to that found near the coal measures on the Hope River. This is succeeded by the red sandstones and conglomerates, which may in some measure be considered as equivalent to our old red sandstone: they dip S.W. near the summit of the Gap. Upon the northern descent from this place there are beds very much resembling those of the southern side; but these latter red sandstones and conglomerates are associated with grauwacke and dip to the N.E. From hence passing down the valley of the Buff Bay River, we find that all the rocks dip more or less to the northward, while those on the south of the Gap dip more or less to the southward.

The submedial or transition country, which comes in to the northward of St. George's Gap, continues nearly to Charles Town, and is composed of the rocks enumerated under the proper head. Approaching the town the grauwacke passes into red sandstone and conglomerate, and the latter support the white limestone formation which extends nearly to the sea.

The section from the sea near Kingston by Half Way Tree, Stony Hill Barracks, and Scot's Hall (Maroon Town), to Forster's Cove (St. Mary's), (Plate XIX. fig. 2.) exposes nearly the same rocks as the above. The diluvial gravel abuts against the base of Stony Hill, which is composed of the white limestone formation, dipping to the southward. This limestone is separated from the porphyritic conglomerate upon which it rests, by light coloured sands and marls, as may be observed on the descent to the Agua Alta, or Wag Water. These are succeeded by a great mass of various trap rocks, among which I here and there observed (in the bed of the Agua Alta) some conglomerate beds, composed of trappean pebbles cemented by a trappean substance. This trap seems to rest upon the red sandstone and conglomerate beds, that pass into grauwacke to the northward of Scot's Hall (Maroon Town).

From thence grauwacke continues across St. Mary's parish to the sea near Forster's Cove, where some of the upper beds of the white limestone formation rest upon it.

The section from Old Harbour to Luidas Vale (fig. 3.) shows the connexion of the trap mountains in St. John's with the white limestone formation on the north and south of it. The alluvial and diluvial plain of St. Dorothy's continues to the base of the white limestone hills near the Rectory, which is itself situated upon a small white limestone hill, that rises out of the plain. The white limestone dips southerly, and continues to Wood Hall estate, where it dips from, and apparently rests on, the trap. The latter afterwards forms the mountains to Mount Pleasant, situated on the mountain that rises to the south of Luidas Vale : here the white limestone again comes in, and rests upon trap rocks. The beds now, however, dip at a considerable angle to the north, appearing as if they were forced up into their present position by the trap ; and a glance at the section will show that the trap has very much the appearance of having been protruded through the white limestone formation, which, it will be seen, returns to its southerly dip on the north side of Luidas Vale. The limestone may have been deposited on the trap, though it is somewhat difficult to conceive how strata, inclined like those between Mount Pleasant and Luidas Vale, could have been formed by deposition from a fluid. Geologists are well aware how difficult it is to refer trap rocks to any particular epoch of formation ; I have therefore not attempted to make any distinctions in this respect between the trap of the St. John's Mountains and that extending through the parishes of Port Royal and St. Andrew's, into St. Mary's: in fact, the trap rocks of the two districts very nearly resemble each other ; and, in both cases, appear from beneath the white limestone formation.

The next section to be noticed is that from the sea, over the Long Mountain, and up the valley of the Hope River, to Catherine's Peak (fig. 4.). A sand-bank (the Palisades) protects the branch of the sea forming Kingston Harbour, on the north of which (in our line of section) rises the Long Mountain, composed of white limestone dipping southerly, and separated by a little diluvium from the sea. Between the Long Mountain and the mountain on the north of the Hope estate we meet with part of the diluvium of the Liguanea plain. This abuts against the porphyritic conglomerate, which forms the gorge of the Hope River Valley near the Hope Tavern, and is continued up the valley to nearly opposite the Botanical Garden, where the rocks which I have described as resembling coal-measures occur beneath it. To these succeed a red and gray conglomerate mixed with light coloured sandstones, among which a compact gray limestone is found, very much resembling the carboniferous limestone of the English series. Beneath these are the red sandstones and conglomerates which I have stated may be equivalent to our old red sandstones.

The rocks of the summit of Catherine's Peak, upon which the above rest, seem to be submedial or transition, and are formed of argillaceous slate, limestone, and gray sandstones: these dip northerly, as may be seen near Clifton (4228 feet above the sea *) and the northern side of Catherine's Peak.

Comparison of the Jamaica Rocks with those described by M. von Humboldt in Mexico and South America which appear to resemble them.

Transition or Submedial Rocks.—The Jamaica rocks of this class can be said very little to resemble those described as occurring in Quito and Peru by Humboldt in his "*Essai sur le Gisement des Roches dans les Deux Hémisphères,*" wherein he states that an immense formation of transition porphyry replaces the grauwacke in those places, and that it is associated with syenite and greenstone. We have seen under the head of trap rocks associated with the Jamaica submedial or transition rocks, that porphyries, syenites, greenstones, &c. are by no means rare on the southern side of the Blue Mountain Range: but these rocks do not replace the grauwacke, on the contrary they are associated with it; and, taking into consideration the mass of the Jamaica transition rocks, the grauwacke and limestones are much more abundant than the trap.

The transition rocks of Mexico, which Humboldt has classed under his group 3, and which he composes of transition slate containing grauwacke, greenstone, dark coloured limestones, syenites, and porphyries, would seem more to resemble the Jamaica transition rocks, for the latter might be classed in this division.

Red-sandstone (grès rouge). The rocks which I have described as red sandstone and conglomerate, coal-measures, and porphyritic conglomerate, porphyries or other trap rocks being associated with the latter, seem analogous to the *grès rouge* and *porphyre secondaire*, which Humboldt describes as occurring in several parts of Mexico and South America, and which he classes together as one formation. Commencing with New Spain, he informs us that the schists and transition porphyries of Guanaxuato (platform of Anahuac) are covered by a formation of red sandstone, that it forms the plains of Celaya, Salamanca, and Burras, and that it supports a limestone resembling that of the Jura. He observes that in the older beds (*mine de Rayas*) he thought he observed a passage from red sandstone into grauwacke: this kind of passage

* According to my barometrical observations.

it will be recollected, I have noticed in two or three places in Jamaica. It is stated, that in the red sandstone of Guanaxuato, the cement is so abundant (road from Guanaxuato to Rayas and to Salgado) that the embedded fragments can no longer be distinguished. Argillaceous beds, from 3 to 4 toises thick, are there seen to alternate with the coarse conglomerate: an alternation of argillaceous beds also takes place with the red conglomerates of Jamaica (Valley of the Hope River, &c). M. Humboldt mentions that he did not observe any traces of coal, or fossil wood, in the red sandstone of Guanaxuato, but that these substances are frequently found in other parts of New Spain.

Under the head of *Venezuela,* it is stated that the immense plains of Venezuela (Llanos of the Low Oronoco) are in great part covered by red sandstone, that the red sandstone is disposed in concave strata between the mountains of the Caracas' coast and those of Upper Oronoco; and that it rests on the north on transition slate, and on the south on granite. This arenaceous formation is covered (Tisnao) by a whitish gray compact limestone, resembling that of the Jura.

In New Grenada an extensive sandstone formation, which M. Humboldt considers to be *grès rouge,* covers nearly without interruption, not only the northern plains of New Grenada, between Mompox, the canal of Mahates, and the mountains of Tolu and Maria, but also the basin of the Rio de la Magdalena (between Teneriffe and Melgar), and that of the Rio Cauca (between Carthago and Cali). Some scattered fragments of schistose coal grit, which he found at the mouth of the Rio Sinu (to the E. of the Gulf of Darien), lead him to think it probable that this formation extends even towards the Rio Atrato and the Isthmus of Panama. It rises to considerable height on the eastern branches of the Cordillera (Paramos de Chingasa and de Suma Paz), and on the western in the mountains between the basin of the Rio Cauca and the Platiniferous district of Choco. It is stated that this sandstone of New Granada may be traced, without losing sight of it, from the Valley of the Rio Magdalena (Honda, Melgar,) by Pandi to the platform of Santa-Fé de Bogota.

M. Humboldt informs us, that in the southern hemisphere, the Cordilleras of Quito presented him with the most extensive formation of *grès rouge* that he had yet observed. This rock covers, at the height of 1300 and 1500 toises above the sea, the whole *plateau* of Tarqui and Cuença; it rises in the Paramo de Sarar to the height of 1900 toises, and the thickness of its entire mass exceeds 800 toises.

The Cuença formation of *grès rouge* is found in Peru, at the great *plateau* of Caxamarca.

From the above it appears that the *grès rouge* of M. Humboldt forms a considerable part of that portion of the American continent which was visited by him, and that it there constitutes a formation of very considerable thickness: it is therefore by no means surprising that we should find it in Jamaica also of considerable thickness, (Valley of the Hope River, &c.) and it is by no means improbable that it may also be found in the islands of Cuba and Hayti.

The Mexican red sandstone is stated to present the most striking resemblance to the *Rothe todte liegende* of Mansfield, to contain angular pieces of Lydian stone, syenite, porphyry, quartz, and hornstone. The cement uniting these fragments is argillo-ferruginous, very tenacious, yellowish brown and often brick red.

This Venezuela *grès rouge* is represented to be a conglomerate, containing rounded fragments of quartz, Lydian stone, and flinty slate, united by an argillo-ferruginous cement, of an olive brown colour, and extremely tenacious. The large-grained conglomerate alternates with a very fine-grained sandstone (Mesa de Paja).

The New Grenada rock is composed of alternating beds of small-grained quartzose and schistose sandstone, with conglomerates containing angular fragments (from 2 to 3 inches in breadth) of Lydian stone, clay-slate, gneiss, and quartz (Honda, Espinal). The cement is argillaceous and ferruginous, sometimes siliceous, and the colours of the rock vary from yellow gray to brownish red.

The *grès rouge* of the Quito *plateau* is stated to be coloured by iron, it is generally very argillaceous, with small grains of quartz; it is sometimes schistose, and alternates, as in Thuringia, with a conglomerate containing fragments of porphyry, three, five, and even nine inches in diameter. Clay beds are found in this formation, sometimes brown, at others white and steatitic, passing into the claystones of the red sandstone porphyries.

From this description of the American *grès rouge*, it will be found to correspond, as nearly as could, from the distances, be expected, with the red sandstones and conglomerates, coal measures and porphyritic conglomerates of Jamaica. Porphyritic pebbles are it would appear more abundant in the Jamaica conglomerates than in those of the opposite continent: this is however a difference of no great importance, as the fragments found in this class of rocks are generally derived from the older rocks of the districts in which they occur.

White limestone formation.—This formation is much more difficult to identify with M. Humboldt's description of American rocks than the preceding.

I am however inclined to consider some of the limestones which M. Humboldt refers to the Jura limestone (oolite formation) as analogous to the Jamaica white limestone, the compact beds of which, as I have before stated, very much resemble those of the Jura in *mineralogical* structure; and I am the more inclined to adopt this opinion as M. Humboldt does not mention that he found any characteristic fossils in the Jura-looking limestones of America, which might lead us to conclude that the formations were distinct. He states that he observed many whitish limestones, in part lithographic, in the equinoctial zone of America. These limestones occur at the cavern of Caripe (on the S. E. of Cumana); on the coast of New Barcelona (Venezuela); at the island of Cuba (between the Havanna and Batabano, and between La Trinidad and the Boca del Rio Guarabo); and among the central mountains of Mexico (plains of Salamanca, and defile of Batas). The limestone formation of the New Barcelona coast contains thin beds of hornstone passing into flinty slate, a circumstance also observable at Zacatecas in Mexico. This is somewhat analogous to the nodules of chert contained in the white marl of the white limestone formation between Annotto Bay and Buff Bay.

M. Humboldt says*: "in the vast steppes of Venezuela, near Tisnao, the *grès rouge* supports, as it appeared to me, a lithographic limestone analogous to the Jura limestone. This also occurs in Mexico, in the plains of Temascatio, to the south-west of Guanaxuato. At the northern extremity of the valley of Mexico (between the Hacienda del Salto, Batas, and Puerto de Reyes) a grayish blue limestone formation, containing gypsum, and supporting a calcareous breccia, appeared to me to belong to the Jura limestone, notwithstanding the proximity of the tertiary marls (Desague de Huehuetoque,) among which the bones of fossil elephants are found." This Jura-looking limestone is also mentioned as occurring at the Caymana islands. While sailing close to the south-eastern shore of Cuba for some distance, I observed that the mountains presented white cliffs precisely resembling those of the white limestone of Jamaica. Should these Jura-looking limestone rocks turn out to be of the same age with the Jamaica white limestones, the latter would appear to have been extensively deposited in this part of the world. That it was so, is by no means improbable; for the Jamaica white limestone formation does not consist of a few thin beds, which might have belonged to a small local deposit, but constitutes an extensive formation, which cannot be less in some places than from 2000 to 3000 feet thick.

In addition to the above rocks which M. Humboldt refers to the Jura lime-

* Essai Géognostique sur le Gisement des Roches, p. 291.

stone, he states, that the hills which skirt the Cordillera of Venezuela in some places by the sea side (Castillo de San Antonio de Cumana, Cerro del Barigon in the Peninsula of Araya, &c.) appeared to him to belong to the *calcaire grossier**. The beds however which he mentions as composing these hills do not agree with the Jamaica rocks, with the exception of the whitish gray compact and arenaceous limestone, which contains madrepores, carditæ, ostreæ, and turbines, and is mixed with large grains of quartz. This last circumstance is not indeed common in Jamaica, but I have observed at Halse Hall a whitish gray calcareous rock, mixed with grains of quartz, resting upon the white limestone, but seeming connected with it.

The very limited extent of country in which I observed volcanic rocks in Jamaica, will render it useless to attempt any comparison with similar rocks on the neighbouring continent. It may however be as well to state that I did not find any trachyte which would seem so abundant in South America.

* Essai Géognostique, p. 312.

XIV.—*Notice on the Geology of the Ponza Isles.*

By G. Poulett SCROPE, Esq. F.G.S.

[Read April 23d, May 7th and 21st, 1824.]

ALL the islands that rise from the Mediterranean off the coast of Terracina and Gaieta are often designated as the *Ponza Isles;* from the name of the central and largest amongst them *.

It would be more correct, however, to consider the three most westerly isles, viz. Ponza, Palmarola, and Zannone, together with the minor insulated rocks that are scattered round them, as one group, and Ventotiene and San Stefano, which are separated from these by a considerable interval, very little less indeed than that which divides them on the other side from Ischia, as a second. These islands are all subject to the crown of Naples. Two only are permanently inhabited or in cultivation, Ponza and Ventotiene. The former has a small but deep and extremely secure port; though a number of half-concealed rocks and sunk ledges near its entrance render it dangerous of approach to vessels of burden unless with an experienced pilot. To the small craft that ply between Genoa and Naples, it affords an invaluable refuge in the rough and variable weather for which the Tuscan sea has been always notorious; and the more important from the perilous character of the whole western coast of Italy, which from Orbitello to Naples consists of a sandy shore, shoaling gradually to a great distance into the sea, upon which a current constantly setting towards the land produces a violent and destructive surf.

In fact a number of boats are annually lost upon this shore, which may be compared to the coast of Lincolnshire, or still more correctly to the low shore of Africa between Cape Blanc and the Canaries. Under such circumstances, the harbour of Ponza, situated in deep water, and at sufficient distance from the main coast to prevent risk in running for it, is probably the means of

* Pliny (Hist. Mund. lib. iii. cap. 6. and lib. xxxii. cap. 11.) mentions Ponza and Ventotiene (anciently *Pandataria* or *Pandateria*) by the appellation of *Pontiæ Insulæ*. They are also mentioned by Livy, Diodorus Siculus, Strabo, Pomponius Mela, Buno in his notes to Cluverius, and others.—See the Map of this group, Pl. XXIII.

saving annually a very considerable number of vessels and lives. During one day that I was myself confined to the island by hard blowing weather, no less than fifteen vessels, occupied in different branches of the coasting trade, put in for shelter*.

These islands were imperfectly described by Sir W. Hamilton in 1785, in the Philosophical Transactions. Dolomieu examined them in the subsequent year, and published his observations in considerable detail in his "*Memoire sur les Isles Ponces.*" But, at that period, geological investigations were almost solely confined to the mineral characters of rocks, or to crude speculations upon their origin; very little attention being paid to their geognostical relations. Owing partly to this cause, and in a great measure to the changes that have since taken place in the nomenclature of the science, few facts of any importance are to be gleaned from the accounts of either writer; and consequently we find these islands unnoticed in most general works on geology: the vague descriptions of the French travellers being perhaps mistrusted, while no more definite or recent observations have been made public by any other geologist.

Still it was known from the account of Dolomieu and from the specimens brought by him to Paris, that these islands consist principally of trachyte, and contain some remarkable resinous and quartzose varieties of this rock, the relations of which became an object of geological interest. It was also known

* A depôt of convicts is established at Ponza, and another on the little rocky isle of San Stefano, an appendage to Ventotiene. In the latter establishment the prisoners occupy a large circular building raised for the purpose; but in the former they are confined to the number of between 500 and 600 in a cavern excavated by the Romans, who probably made use of it for the same purpose, since these islands are known to have been occasionally made the place of exile for state prisoners[a]. Stone-quarries appear to have been in frequent use among the ancients as prisons[b]. When the health of prisoners was entirely overlooked, and security and œconomy the only objects considered, such crypts or grottos offered considerable advantages, and many appear to have been excavated with a view to such an ultimate adaptation. This den, for it deserves no other name, has but two narrow spiracles cut through the rock to the surface of the hill above, by which either light or air can be admitted, and these are closed at night. Indeed from the narrowness and vertical depth of these openings, little exchange can be supposed to take place between the foul air below, and the purer, drier, and therefore lighter atmosphere without. Unless we suppose the porous trachyte and tufa forming the walls of the cave to be permeable to atmospheric air, it is difficult to account for the fact, that, whatever disease is engendered in so foul a dungeon, still the air remains respirable to so many human lungs, notwithstanding the impediments by which its renovation appears to be opposed during the day, and the apparently total obstruction to it at night.

[a] *Vide* Tacit. Ann. lib. i. cap. 53. et lib. xiv. cap. 63. Sueton. in Tib. cap. liv. et in Caligul. cap. xv.

[b] *Vide* Thucydid. lib. vii. cap. 86 et 87.

that the examination of them is facilitated by the constant degradation of their steep and naked cliffs, occasioned by their exposed situation in a boisterous sea of great depth, and the friable nature of many of their component rocks.

The few trachytic districts which have been as yet examined with attention, and according to the improved method of modern science, occur inland, and great difficulty has uniformly been experienced in every endeavour to ascertain the relative positions of the different varieties that compose them; a difficulty perhaps exaggerated by the prepossession for some favourite theory, but chiefly owing to the facility with which the rocks of this family yield to the wasting influence of the weather; in consequence of which their debris usually reach to so great a height against their escarpments, that few natural sections of any extensive surface are to be obtained. In traversing such inland districts the observations of the acutest geologist are almost necessarily limited to geographical data; the intervals between the knolls or protruding masses of different varieties being concealed by detritus. This is a source of peculiar obscurity among the trachytic formations, which, being unstratified, give no indications, by the dip of their beds, of the relative positions of their discordant members. Vertical sections in this case are invaluable, and without them the geological observer is liable to be led into unavoidable and pernicious errors. So general indeed and fatal is this difficulty, that there still exist doubts in the minds of geologists of great experience, and who have had opportunities of examining more than one trachytic district, (but under the disadvantages to which I allude,) as to whether this rock ever occurs in absolute superposition to any other.

For these reasons the Ponza Isles, whose internal structure is completely laid open in the surfaces of their worn and skeleton forms, become objects of considerable interest, notwithstanding the comparative smallness of their extent.

Such were the considerations which induced me to visit them in the beginning of May, 1822. I was on the whole very fortunate in weather, and was enabled by the calmness of the sea to explore almost every part of them at leisure, making the tour of each in a boat, and landing wherever it was judged necessary to examine more closely the composition of the cliffs by which they are invested.

Ponza.*

This, the largest island of the group, has a very remarkable figure; of extreme length in comparison with its width. The former may be estimated at little more than four miles; its width is exceedingly unequal. The shores are eaten into numerous deep concavities, seemingly produced by the undermin-

* See the Map, Pl. XXIII.

ing action of the waves wherever the component rock was more friable than that of the intervening promontories. When these points of extreme erosion accidentally correspond on either side, the island is very nearly divided by the junction of the two opposite coves. This occurs to a remarkable degree on two different points of the island's length, in which its transverse diameter does not exceed a few hundred feet. It is probable that in no great length of time a complete separation will be effected on both these spots; one of which is the narrow strip of land that divides the cove called Chiaja di Luna from the harbour of Ponza; the other, a still narrower ridge which backs the Cala d'Inferno, and is now continually sapped by the breach of the sea on either side.

Such a disjunction appears already to have taken place in more than one instance at the northern extremity of the island, where a narrow channel cuts off from it the little circular islet called La Gabbia; and further on in the prolongation of the same direction, (which is that of the longitudinal extent of the main island,) three or four insulated rocks rise above the water-level, identical in constitution with the nearest extremity of Ponza, and connected with it by a reef which may be traced by soundings, and seen on many points when the sea is calm. The island of Zannone stands at no great distance further on in the same line, and forms the extremity of this range of submarine heights. The proofs of rapid and continual destruction visible in the main island of Ponza, render it probable that the remaining insular eminences of this chain were once united even above the sea level.

The island does not offer a single uninterrupted and central ridge or axis with a gradual slope on either side, as is often the case with such strips of elevated land. Its present form rather leads to the supposition that it once consisted of two parallel but irregular ridges, branching off from the massive eminence which terminates the island to the south. Of these ridges the westerly one is almost wholly worn away by the violence of the swell to which this quarter is almost incessantly exposed. The few more durable fragments that remain of it, project as capes into the sea, rising in height from the interior of the island to their extremity, where they terminate in an abrupt cliff, thus reversing the general figure of ordinary promontories. The eastern range of hill not being subjected to so constant an erosive force, is less degraded. There are, however, few points on which any portion of its seaward slope remains, the perpendicular escarpment of its water-worn face dropping in general directly from the acute edge of the opposite or landward slope.

A number of pointed and picturesque rocks of columnar trachyte rising from the sea on either side of the island, at short distances from its steep cliffs, add to the proofs of its greater original width, in the same manner as those

which connect Zannone and La Gabbia, indicate its former extension in a longitudinal direction. Besides those which appear above the water-level, there are many sunk rocks between and around them. At a certain distance however from the island, the water suddenly deepens and becomes unfathomable.

The southern extremity swells into a bulky and rounded eminence called La Montagna della Guardia, a name common to the principal height of almost every island in the Italian part of the Mediterranean, and derived from the look-out which till within a very few years was necessarily kept there day and night, to give notice of the approach of the Barbaresque corsairs, which were in the habit of paying frequent spoliatory visits to these straggling and unprotected islands. This mountain, if it may be called so, rises to about 800 feet above the sea, while no other point of the island exceeds 500. It has a gradual and concave slope on the north-east towards the circular cove which forms the port, and the neck of land which connects it with the remainder of the island. On every other side it is bounded by cliffs, with or without a talus at their base.

Throughout the remaining circumference of the island, in consequence of the depth of the sea by which it is continually corroded, and, probably, by reason, also, of the existence of some marine current which sweeps away the detritus of its shores, no accumulation of fragments appears to take place at the foot of their escarpments. These, therefore, present the most complete natural sections, in which the constitution of the island may be studied with the greatest facility.

The brilliant whiteness of many rocks, the strongly contrasting colours of others, their remarkable forms, and the irregular manner in which they are mutually disposed, give an extraordinary and striking aspect to the island, particularly when approached from the east. The range of cliffs on this side, seen from a short distance, presents the characters of an ideal geological section coloured with conventional tints to distinguish the different rocks which compose it. The colours made use of for this purpose in the accompanying sketches are the same as in Nature, and scarcely deepened in tint.*

The substance of the island, with the exception perhaps of the massive bed which forms the capping and the southern front of the Montagna della Guardia, is trachyte †. This rock, however, varies considerably, and frequently

* See Plates XXIV. and XXV.

† Trachyte occurs so rarely, if at all, in this country, and appears in consequence to be so little known amongst English geologists, that I may be perhaps pardoned for introducing here a brief description of its general characters, and principal specific varieties.

Trachyte, then, is a rock composed essentially of felspar at least in the proportion of 90 per

in character. The mineral composition of these varieties is very similar. All consist principally of felspar, and differ only in a greater or less admixture of mica and quartz.

The rock, which from its superior durability appears to support and strengthen the less solid parts with which it is intimately associated, is universally prismatic, and generally divided into groups of small but very regular columns, from which common character I will distinguish it for the present by the name of *prismatic trachyte*. Its predominant colour when broken is grayish or whitish yellow, mottled with irregularly parallel streaks of a pinkish

---

cent. Its specific gravity does not exceed 2·80. It is fusible before the blowpipe into a white or grayish white enamel. Its other occasional ingredients are hornblende, augite, mica, titaniferous iron, magnetic iron, and quartz. One or more of these minerals appears to be always present.

The texture of trachyte varies from coarsely crystalline or granitoidal, to earthy, fine-grained, scaly, and compact; and finally to resinous and glassy (obsidian).

Sometimes the grains or minute crystals of which it is composed are of uniform size, and the structure of the rock is *simple*. In general, however, the size of these elements is very unequal, and it assumes a *porphyritic* structure; the larger crystals distinguishing themselves from the base or enveloping matter of finer grain.

These distinct crystals consist of some or all of the different minerals enumerated above as entering into the composition of the rock.

Those of felspar are frequently striated and even fibrous. The mica appears usually as hexagonal or rhomboidal plates or prisms of great regularity. Hornblende shows itself in acicular crystals. Titaniferous iron in octahedrons or minute grains. Quartz occasionally in rounded grains, more rarely in hexahedral prisms terminated pyramidally at one or both extremities.

The *internal structure* of trachyte embraces the following modifications: viz.

The compact, porous, cellular, vesicular, cavernous, and filamentous.

In its *divisionary structure* it presents occasionally the massive, columnar, prismatic, tabular, laminar, schistose, globular, or angulo-globular forms.

Its characters of lustre and fracture will be of course decided by the texture, those of hardness by the texture and mineral composition.

N.B. The granular and earthy varieties of this rock have by some geologists been called *claystone*. The scaly and laminar, *clinkstone*. The compact, *compact felspar*, or *hornstone*. The resinous, *pitchstone;* and the vitreous, *obsidian*. The vesicular and filamentous varieties of glassy trachyte pass currently under the name of *pumice*, and the globular concretionary variety, under that of *pearlstone*.

These names, which it will be well to retain, must not yet prevent our recollecting the rocks to be all mere varieties of the *genus trachyte*, characterized by differences of texture and internal structure.

I use the term *trachyte* in preference to that of *claystone*, the English synonyme for its most ordinary variety, since it leads into no error as to the nature of the rock, which being in general more or less crystalline, and containing occasionally above 90 per cent of silex, has little in common with clay. Trachyte appears to be universally of volcanic origin. It occurs in the volcanic districts of France, Italy, the Rhine, Asia Minor, and the Archipelago: in the Azores, Leeward Isles, and the Andes of both Americas.

brown, ochry brown, or blackish blue tint. The surface of the columns, and consequently the natural face of the rock, is of an ochry brown, apparently produced by the infiltration of an oxide of iron. The ferruginous matter has frequently penetrated to the interior of the prisms, producing rows of concentric stripes, usually parallel to the outer surface, and wholly independent of the direction of the other streaks or zones, mentioned above. The latter distinguish themselves by alternations of different texture as well as colour, the darker layers being universally more compact and fine-grained, as well as harder than the intervening parts of a lighter tint.

These zones traverse uninterruptedly a great extent of rock, without any regard to the position of the columns, and generally cutting them at some angle to their axis; thus indicating, that a partial modification of internal structure in the substance of the rock, preceded its separation into prismatic concretions. They are not necessarily straight, but frequently waved or contorted in concentric curvatures, like the stripes of certain varieties of marbled paper; and this both on the large and small scale. The thickness of the streaks varies from some inches to that of the finest thread. This variegated appearance is at times exchanged for one in which the rock assumes the character of a breccia of fragments of different colours and grain embedded in a zoned basis. This latter variety generally occurs towards the extremity of the mass, and where it loses its prismatic division.

This species of trachyte usually exhibits an earthy-granular base, consisting of felspar, with numerous imbedded plates of mica, hexagonal or rhomboidal, but seldom entire, and imperfect half-fused crystals of glassy felspar. It is porous, particularly the more earthy and lighter-coloured laminæ, and the direction of the porous parts as well as of the vacuities themselves, coincides with that of the stripes. The dark-coloured zones are not only of a finer and closer grain than the intermediate layers, but harder and apparently more siliceous; in some places they become so compact, as to communicate to the rock a sharp and splintery fracture approaching to conchoidal, and a flinty aspect. This is particularly the case, where it resembles a breccia. On these points the rock flies, when touched by the hammer, in the manner of flint, and rings like glass. The imbedded fragments are often, not always, equally siliceous with the base, and so firmly cemented to it as never to separate at the line of contact. They seem to be portions of the zoned or variegated trachyte, broken off by friction before the whole was consolidated, and enveloped in the parts which still remained liquid*. Where the alternate zones are most contrasted in colour and texture, the whiter and more friable ones

* In the manner of the brecciated marbles, jaspers, &c.

show a minute spherolitic structure*. The globules are of felspar, generally hollow, and internally ragged and angular. The base is compact, fine-grained, somewhat siliceous, and of a dark gray or a reddish brown colour. Complete and gradual transitions from this to the ordinary zoned or marbled variety may be observed within the compass of the same block; the spherolitic concretions increasing in number, and appearing drawn out into a long ellipsoidal or lenticular form, until they form together a whitish earthy zone or vein; while the intervening compact matter is equally stretched out into stripes which retain their colour and texture. These passages lead me to be of opinion that even where no traces of spherolitic structure are visible, the ribboned arrangement of the rock is owing to the mass of matter having been drawn out in the direction of the zones while still liquid, after a previous separation had taken place of the feldspathose spherolites, (which are analogous to the vitro-lithoid globules of glass furnaces,) and the impure semi-siliceous base. A close examination of these zones, makes it obvious that the finer and darker parts possessed a higher fluidity than the earthy and more feldspathose ones, and that the different degrees of mobility of these alternate layers, was the chief cause of their irregular wavings and contortions. Almost every distinct crystal of felspar or mica may likewise be observed to have produced a similar irregularity in the neighbouring zones, proportioned to its size and form, by the resistance it offered to their freedom of motion. The elongated crystals of both minerals have generally taken the direction of the movement, their longer axes lying more or less in the plane of the zones; and frequently a single crystal of felspar will appear to have been broken up and carried away piecemeal, by the friction of the neighbouring laminæ, leaving a train of half-fused fragments with empty spaces between them.

The columns into which this rock is divided assume every direction, though with a general tendency to the vertical. They are sometimes united into fan-shaped clusters. At others, the rock appears separated into irregular vertical beds, composed of columns arranged in bundles, like faggots, and disposed horizontally, or nearly so; their axes being always perpendicular to the sides of the bed or vertical seams. The width of the bed is always proportioned to the diameter of the columns. They are sometimes bent in one or more directions, preserving however their general parallelism, and recovering by degrees the straight direction on either side. They are usually small, and the smallest are the most regular. Very perfect five- or six-sided prisms, from

* Similar to that of some of the Hungarian trachytes, the *porphyres trachytiques* of M. Beudant.

half an inch to four or five in diameter, are closely grouped together, in vast numbers, into clusters; and by the sharpness of their angles, seen in the perpendicular face of the cliffs, exhibit an appearance, which was compared both by Dolomieu and Hamilton to some kinds of Roman brick-work. Those columns which are piled horizontally are universally the least and shortest, the vertical ones much longer and of greater diameter.

The superior hardness of this rock, aided probably by its prismatic structure (which under a certain arrangement of the columns adds to the durability of the mass as much as a different disposition often facilitates its destruction), has enabled it on many points to resist the breach of the sea more effectually than the other varieties of trachyte, and the conglomerates. Hence it constitutes most of the insulated rocks that surround the island; its columnar structure adding much to the picturesque effect of their outline. The prismatic trachyte also forms a large part of the main island, particularly of its southern moiety. It abounds throughout the range of vertical cliffs of the whole eastern shore, as well as on the opposite side of the island from the Punta del Fielo to that de' Faraglioni.

In these natural sections it is constantly accompanied by a rock which I am about to describe, with which it alternates in irregular massive beds, assuming every possible direction, except perhaps the horizontal.

This other rock may be designated as a

Semi-vitreous Trachytic Conglomerate.

In its ordinary character it consists of an earthy and very friable substance of a pure white or grayish white colour, inclosing numerous fragmentary blocks of an ash gray or grayish green semi-vitreous trachyte, which have in general much of the fibrous structure and elongated cells of pumice, are extremely brittle and light, and occasionally pass into common glassy pumice.

On a close examination the basis of the rock appears to consist of pulverulent particles of the same substance. It crumbles easily, and seldom possesses sufficient solidity to allow a specimen to be preserved entire. The inclosed fragments reach the size of a foot or more in diameter. They contain imbedded glassy felspars and bronzed mica. These crystals occur also, but less frequently, in a loose state in the earthy base. Some few of the fragments consist of trachyte without any glassy lustre, and resembling the prismatic trachyte described above, or other varieties not met with *in situ* in the island. One large block which I took out of this conglomerate was identical with the loose crystalline trachytic lava of the Monte Tabor, in Ischia, of a dead leaf colour, with numerous large and distinct crystals of glassy felspar. None of the frag-

ments are water-worn, and they all have evidently been enveloped in the base immediately upon their ejection by the volcanic impetus. They cohere strongly to the matrix, but are separated from it by decided fracture lines, which, as well as their variety and number, make it impossible to doubt that the rock is essentially a conglomerate, in spite of the remarkable passages it exhibits by insensible gradations into rocks of a different character.

The inclosed fragments, from their superior solidity, protrude from the weather-worn surface of the cliffs, and protect the line of rock, immediately beneath, from the rain by which the more exposed parts on either side are corroded, giving rise to pyramidal or buttress-shaped masses, each capped by one of the larger blocks, and standing out from the front of the escarpment in parallel rows. When these are in considerable number, an effect is produced which may be easily mistaken at a distance for the result of a columnar division*. The rock is on the contrary amorphous, with the exception of an obscure appearance of irregular stratification, which shows itself in some masses, the larger fragments being arranged in parallel lines like the flints of our chalk-beds, a character far from uncommon amongst the volcanic conglomerates.

It has been observed, that the prismatic trachyte and this conglomerate are associated confusedly throughout the greater part of the island, interrupting each other alternately with an irregularity of direction of which the accompanying profiles will convey a clearer idea than any verbal description. The general impression arising from an examination of all their relations, is that the prismatic trachyte has broken through the conglomerate from below, and forms irregular intruded masses or dykes within it. On some few points, however, the former rock appears to have overspread the surface of the latter, and to have been in turn covered by other beds of conglomerate.

Change observable at the point of contact of the Conglomerate with the Prismatic Trachyte.

It is remarkable that throughout the numerous sections afforded of the common boundary of these two rocks, in the precipitous shores of the island, the

* The process by which these buttresses are worked out is the same which produced and continues to augment the number of the celebrated pyramids formed out of alluvial soil near *Botzen in the Tyrol.* The spiry and pinnacled forms assumed by conglomerates of all ages are probably owing to the influence of the same causes. Even where the protecting fragment has at length fallen, from the gradual mining of its support, that support still continues to wear away in a pyramidal form, from the equal action of the vertical fall of rain upon all its sides.

conglomerate is found almost without a single exception to be *altered* at the plane of contact with the prismatic trachyte.

This alteration extends from two to thirty feet in depth when the natural section of the rock cuts the plane of junction at right angles. When its direction is oblique or partially parallel to that plane, of course the alteration extends over a much larger surface of the bare cliff, and at first induces the false notion of the existence of very considerable masses of the altered rock. This consideration must be borne in mind in studying the profiles of these cliffs.

The change consists in the gradual transition of the white and earthy base of the conglomerate, as well as of the cellular and glassy fragments it incloses, into a compact *resinous* trachyte or *pitchstone porphyry*, of a dark bottle-green colour, containing numerous crystals of glassy felspar and bronzed mica, and breaking readily into lamellar and rhomboidal fragments. This at least is its predominant character: occasionally it exhibits a testaceo-globular structure, becoming a pearlstone similar to that of Iceland and the Andes, of a greenish-gray colour and pearly lustre. In other places it assumes a still more regular globular concretionary division both on the large and small scale. In the latter case the rock resembles an aggregation of beads, breaking into concentric layers; this variety contains cellular and fibrous parts like the vesicular obsidian of Lipari. The large globiform structure is strikingly exemplified in a rock which projects from the cliff within the Chiaja di Luna, near the entrance of the Roman gallery *. The alteration appears here to have proceeded to a great depth; and the globiform structure occurs in that part of the pitchstone bed which is nearest to the junction with the prismatic trachyte. The rock shows a tendency to the columnar division, the columns separating into large globes or ellipsoids, placed one above the other. These balls, when they have been exposed a short time to the weather, desquamate at a touch into numerous concentric coats, like those of a bulbous root, inclosing a compact nucleus, of which the laminæ have not been sufficiently loosened by decomposition; though the application of a ruder blow will produce a still further exfoliation. The globes vary from a few inches to three feet in diameter. This structure passes not only into the columnar, but also into the lamellar; the lamellæ being either straight or twisted into the most intricate contortion. The longest axis of the ellipsoids is invariably in the direction of the lamellar or prismatic system to which they belong.

These varieties of natural division are certainly not produced by decomposition, which has evidently only assisted in disclosing an original configuration.

* See Plate XXIV. fig. 4.

In the globular pitchstone this process has been accelerated by the quantity of cubic pyrites disseminated throughout it. Sometimes, in the immediate vicinity of the prismatic trachyte, the pitchstone incloses small nuclei of obsidian of an olive green colour, translucent at the edges, and with the conchoidal fracture of glass; and the pitchstone becomes more fine-grained, compact, and homogeneous the nearer it lies to the boundary of the prismatic trachyte.

This boundary is universally an abrupt and decided separation; but, on the other side, the former rock graduates insensibly into the earthy and friable conglomerate, passing through a modification of pitchstone of which the predominant colours are an orange-green and a waxy yellow. It contains the same minerals, and has the same texture and lamellar structure as the dark bottle-green pitchstone; except that, as it recedes from the latter rock, it becomes less compact, and slightly porous. The conglomerate structure may be traced very clearly through this intermediate rock. The imbedded fragments sometimes assume the resinous lustre and texture more completely than the base: sometimes the reverse takes place; probably according to the original nature of the fragments. When these were of earthy unvitrified trachyte, they have resisted more or less the agency which tended to reduce them to pitchstone, and remain visibly enveloped in the more resinous base. This often exhibits a wrinkled appearance incircling these refractory fragments, from which it appears to have possessed a partial fluidity. This rock is frequently penetrated by minute veins filled with a white earthy substance, of a feldspathose character; they traverse both varieties of pitchstone, and ramify into the conglomerate without changing their direction. In the Chiaja di Frontone, two vertical dykes, averaging two feet in width, cut through the green pitchstone, which appears here of unusual extent. They are filled with a loose white trachytic conglomerate, extremely fine-grained. It was probably washed into fissures of the rock by the water which held it in suspension.

The constant occurrence of these bands of green and yellow pitchstone at the junction of the prismatic trachyte and the semi-vitreous conglomerate *, and the easy gradations of colour, texture and structure, by which they invariably pass into the latter rock, unquestionably prove them to proceed from its alteration by contact with the prismatic trachyte. In fact, this rock, as has been already noticed, bears on most points the appearance of having forced its way upwards by cutting through the incumbent conglomerate in various directions, and occasionally of having spread laterally over it. Its regular co-

* See Plates XXIV. and XXV.

lumnar division, which has without doubt been assumed subsequently to the occupation of its actual position, proves it to have been protruded in a state of liquidity, or at least of softness.

This liquidity as well as its elevation could only have been the result of intense heat, and it may therefore easily be believed to have effected the partial fusion of the fine and loose base of the feldspathose conglomerate, and of the imbedded fragments, of this rock, (already in a semi-vitreous state, and therefore more easily fusible,) with which it came in contact. The compactness of texture resulting from this imperfect fusion, as well as the local varieties of concretionary structure, are probably owing to the pressure and friction sustained during the forcible protrusion of the prismatic trachyte, and locally modified by accidental circumstances. The porphyritic character of the pitchstone will not prevent our recognising it to proceed from the fusion of an earthy conglomerate rock, since both the fragments dispersed through the unchanged rock are themselves porphyritic; and the earthy pulverulent basis incloses broken crystals of felspar and mica, which in the pitchstone porphyry have only been rendered more visible by the semi-fusion and discolouration of the finer and less refractory matter that envelops them.

The semi-vitreous conglomerate appears on some few spots to inclose irregular and indistinct beds of a very earthy trachyte of an ash-gray or yellowish white colour, with numerous felspar crystals and plates of mica. Its hardest parts are identical with the prismatic trachyte, but it does not ever like this assume a columnar division. It is often slightly zoned with brownish yellow streaks, and is fissile in their direction. From the earthiness and loose texture of its base, it is seldom possible to determine its line of separation from the earthy conglomerate with which it is intimately associated, and which is evidently of contemporaneous formation. For this reason no attempt has been made to distinguish the two rocks in the accompanying profiles. Where this earthy trachyte comes in contact with the prismatic, it suffers the same alteration as the neighbouring conglomerate, being converted to a certain distance into green pitchstone, or more frequently into a pearlstone, which exhibits superficially a kind of bloom similar to that of a plum, and contains some white and cellular parts.

The alternations and mutual interruptions of the rocks above described will be observed, from the plates, to be repeated throughout the Southern half of Ponza. Towards the Northern extremity the prismatic trachyte almost entirely disappears. With the exception of a pyramidal mass of rock which forms the extreme point called the Punta dell' Incenso, opposite the Islet of La Gabbia,

it is not visible, on the eastern face of the island, beyond the Chiaja del Schiavone; nor on the western, north of the Punta de' Faraglioni.

The cliffs within this space are composed of the semi-vitreous conglomerate to a certain distance, beyond which the mass of the island consists solely of an anomalous rock of very variable and singular characters, and constant only in its extremely siliceous nature. From this circumstance I may distinguish it by the name of

Siliceous Trachyte.

In their external features, the escarpments formed of this rock, and exposed to the erosion of the sea-spray and meteoric agents, strongly resemble the siliceous burr-stone of the Paris Basin, having the same carious, hatched, and angular surfaces. Their predominant colour is yellowish white or gray.

Under its most general form this rock offers a white earthy and friable substance traversed by irregular concretionary parts of a compact texture, an ash-gray colour, and often a flinty lustre. These usually constitute the greater part of the rock. The earthy portions cut with the knife like fine chalk, which they exactly resemble in outward appearance. Their whiteness is often of the purest and most dazzling brilliancy; and their detritus carried off by the rain from the rocks in the interior of the island, is collected from the beds of torrents, and made use of as whiting by the inhabitants. The compacter parts seldom yield to the knife at all. Both appear to consist of nearly pure silex, and are fused with the greatest difficulty by the blowpipe. They contain a few disseminated crystals of mica, which are in general wholly or partially decomposed into an ochry earth. The fissures of this rock are often lined with ferruginous dendrites, or with a coating of delicate quartz crystals.

By degrees the compact parts predominate still further, and inclose numerous very perfect crystals of felspar, some of which are in the state of kaolin, while others are glassy and brilliant, roundish grains of pellucid quartz, and a few rare crystals of black mica. The basis of this porphyritic rock is close grained, and exceedingly siliceous. It is heavy, solid, and tough; of straight and rather uneven fracture, a clear grayish white colour, and strikes fire readily with steel. Through this rock the white earthy parts only appear scattered in irregular patches, giving it a brecciated aspect; and often disappear altogether for a considerable space. At the northern extremity of Ponza, west of the Punta dell' Incenso, this quartzose porphyritic trachyte is traversed by an irregular vertical vein, from six inches to two feet in diameter, which incloses where it is widest a number of fragments of the same rock evidently broken off from the sides. The vein is filled by a blackish clay studded with cubical iron pyrites with a smaller proportion of copper,

accompanied by crystals of quartz. This ore, as well as the crystals, is attached in greatest quantity to the sides of the vein and the surfaces of the fragments it incloses, coating them over with a metallic crust, and impregnating the substance of the rock to a certain distance with disseminated pyrites. A brown and yellow clay iron ore also encrusts the sides of the vein in some spots, and stains the rock to which it is attached, to the depth of a few inches. The washing of this vein by the sea-spray and rain clothes its exposed surfaces with a coating of green carbonate of copper.

On the west side of Ponza, and particularly within the Chiaja delle Forne, this siliceous trachyte presents the appearance of a coarse breccia. Irregular masses of a fragmentary aspect seem to be cemented by a less compact, and often very earthy basis, into which however they may be often observed to throw out venous ramifications, or pass by insensible gradations. If, therefore, they were originally fragments, most of them must have been enveloped before they were entirely hardened, as was conjectured above in the case of the siliceous and brecci-form parts of the prismatic trachyte.

These blocks are generally ribboned or mottled with blue, brown, red, yellow, light-green, white, and an infinity of intermediate tints. Their texture is usually close, fine grained, and flinty. They also possess the lustre and general aspect of flint; sometimes the grain approaches to that of chalcedony, and the cavities are lined with a mammillated coating of this substance which graduates into the surrounding rock. Imbedded plates of mica and imperfect felspar crystals occur in them. In the earthy parts the mica is usually decomposed into rusty specks. This rock rings like glass under the hammer, and flies into exceedingly sharp-edged fragments, translucent at the edges.

It is in general heavy and dense; but in some parts becomes light and porous; the cells are then elongated in parallel lines. The crystals of felspar and mica appear drawn out in the same direction; the former broken up and half fused. In this state it appears passing into pumice, but is equally siliceous with the compacter parts. It is often intersected by veins of almost pure quartz of a milk-white colour; some of these are 3 or 4 inches in width, and are cancellated, or formed of plates crossing one another, so as to leave angular spaces between them. In disposition and aspect they are very similar to the quartz veins of granite and gneiss. Where any fissures occur, they are lined with quartz crystals. Amongst the massive blocks inclosed in this brecciated rock, I observed one of extraneous origin. It is granitoidal, composed of glassy felspar, quartz, and a very little mica. This fragment left its impression in the siliceous rock, on being detached, while the other masses of fragmentary appearance will not separate along their seeming boundary lines.

Towards the upper parts of this extremity of the island, and particularly at the summit of the cliffs which face the east between the Punta dell' Incenso and the promontory marked δ in the map, the siliceous trachyte passes into another variety of rock, also of a fragmentary character, which wherever it has been long exposed to meteoric action is rendered extremely carious, and acquires a dead-leaf or iron-rust colour, with a dull earthy aspect. The fragments generally appear fibrous like pumice, and are united together by a siliceous cement. This cement resists decomposition, while the fragments it envelops have decayed to a considerable depth into a sort of clay, which mixes readily with water, and is therefore easily carried away by the rains; and hence arises the cavernous and corroded character of the exposed parts of the rock *. The fragments themselves also decompose unequally, from containing alternate hard and softer zones, and their fibrous aspect is in great part derived from this circumstance. This rock in its unaltered state is traversed by irregular fissures, which are lined with numerous groups of quartz crystals, some measuring an inch in length, having frequently an amethystine tinge, or coated with red oxide of iron. Some of the fragments also appear to be agglutinated by limpid quartz and oxide of iron.

Such are the different varieties of this singular rock; all of which pass insensibly into one another. It is not easy to determine the real relations of the *siliceous trachyte* to the *semi-vitreous conglomerate* which succeeds it on the south. At the western side of the island the former rock seems to overlie the latter; but in the cliffs on the opposite shore their position is reversed. At each spot the limits of the two rocks are evanescent, and it is impossible to say where one ends and the other begins. This uncertainty is perhaps occasioned in part by a mutual penetration taking place along their common boundary, but chiefly by the difficulty of distinguishing the white earthy base of the conglomerate from the equally white and earthy parts of the siliceous trachyte.

The small cap-shaped islet called *la Gabbia*, which is divided from the northern extremity of Ponza by a narrow strait, consists entirely of siliceous trachyte, presenting the same varieties as in the main island.

From the above details, which will I fear be found tediously minute, but which were rendered necessary by the complex and singular nature of the rocks to be described, it will appear that the trachytic rocks of the island of

* The resemblance which it bears to the most cellular of the Paris burr-stone arises from the identity of the process which both rocks appear to have undergone.

Ponza are distinguishable into two masses; the one an earthy trachyte, pretty uniform in structure and composition, associated with a conglomerate of pumice and semi-vitreous trachyte, which is almost universally converted into pitchstone near the former rock: the other a very quartzose porphyritic trachyte of a novel and anomalous character, which is also accompanied by breccias and conglomerates equally siliceous.

The relative positions and mutual interference of these varieties will be best understood from the accompanying outline sketches of the principal cliff ranges of the island*.

The most interesting of these natural sections is that which circumscribes the Chiaja di Luna, a deep semi-circular cove opening to the west, and corresponding to the harbour of Ponza, a similar indentation of the eastern shore, from which it is only separated by a narrow and rocky isthmus. Across this the Romans, when masters of Ponza, effected a communication for land carriage between the opposite bays by means of an arched gallery cut through the rock of prismatic trachyte and lined with reticulated brick-work. This passage still remains entire, and carries off the waters that drain down the concave slope of the Montagna della Guardia towards the port, which would otherwise do considerable injury to the town and quays, by wearing away the friable conglomerate on which they are chiefly built.

The cliffs forming either horn of this crescent (the Chiaja di Luna†) present the usual irregular intermixture of the prismatic trachyte and semi-vitreous conglomerate; the latter invariably passing into pitchstone towards its line of contact with the former. The central part of the curve is occupied by a deep bed of loose earthy tufa (trachytic conglomerate)‡. Both the upper and lower parts of this mass contain coarse fragments of pumice and compact trachyte; disclosing its stratification, which in the intermediate bed is not perceivable from the uniform fineness of the fragmentary matter. This rock contains a few broken crystals of felspar and mica, and a large proportion of magnetic iron-sand. Its characters are very distinct from those of the semi-vitreous conglomerate already described; it possesses little or no coherence, and incloses none of those blocks of glassy trachyte which are charac-

* See Plates XXIV and XXV.

† See Plate XXIV. fig. 2.

‡ Tufa is the trivial name adopted by the Italian geologists to designate all volcanic conglomerates of a feldspathose nature, which are composed principally of pumice. The conglomerates of basalt or leucitic rocks they term peperino. The first term is totally distinct in meaning from *tufo*, which is never applied to any other rock than calcareous tuff, and is rarely used at all, its synonyme *travertino* being generally preferred.

teristic of the other rock. A similar conglomerate occurs on other neighbouring parts of the island, but never shows any signs of disturbance, always overlying the rocks already described, and adapting its strata to the irregularities of their surfaces.

In the instance under consideration, the disposition of these fragmentary strata proves them to have been deposited subsequently to the formation of the prismatic trachyte against which they lean on either side; apparently filling a deep chasm between these two masses, which in all probability was the result of some violent convulsion. This observation may appear superfluous, but is called for by the resemblance of the nearly vertical bed of trachyte on the right side to a *dyke* or intruded mass. Its evidently posterior origin to the tufa which bounds it on one side, proves that it cannot have been really produced in that manner.

The natural section of this bed of tufa presents an absolutely vertical wall about 300 feet high; which being sapped by the waves whenever the westerly winds blow directly into the cove, peels off at intervals in massive laminæ, and thus continually offers a fresh surface.

Beds of a similar conglomerate, probably once a continuation of the same mass, are observable on the south side of the cove. One portion of them has been deposited on the uneven and concave surface of a mass of prismatic trachyte, all the strata following the sinuous outline of the latter rock. Another set of strata lie horizontally across the edges of two neighbouring masses of the prismatic trachyte and semi-vitreous conglomerate, as well as of the former waved tufa, all of which must have simultaneously suffered a certain degree of denudation before its deposition. These beds of tufaceous conglomerate contain large fragments of all the varieties of trachyte mentioned above, which have the aspect and forms commonly met with in the ejected blocks of volcanic conglomerates.

Another series of similar strata, and equally to all appearance a continuous part of the same deposit, shows itself on the opposite side of the island, forming a line of cliffs which range southward from the Punta della Madonna, at the entrance of the harbour of Ponza*. These also rest indifferently upon the prismatic trachyte and semi-vitreous conglomerate. No alteration is ever observable in them at their boundary with the former rock; their separation from the latter is equally decided and complete. Both had evidently been consolidated before their deposition, and have remained undisturbed ever since. The same tufa crops out on two or three other points towards the base

* See Plate XXIV. fig. 1.

of the Montagna della Guardia, and forms a partial covering to the slopes of the hills to the north and west of the harbour.

This stratified conglomerate is in turn surmounted by the huge bed of rock which caps the Montagna della Guardia, and occasions its superior elevation over all the other heights of the island, where no subsequent formation covers the primary trachytes.

This rock varies in colour from a dark iron gray to a reddish or purplish gray and lead blue. It is uniformly dense, heavy, and extremely hard, striking fire readily with steel, and so tough that specimens can with difficulty be obtained from it by a hammer of the largest size. Very few porous parts are observable. It appears to be composed principally of crystalline felspar, varying in the size of the grain from the compactness of some clinkstones, which it then resembles, to a coarse granitoidal aggregation of large and brilliant but imperfect crystals of gray or reddish white felspar, with a few small crystals and numerous minute grains of augite, and some hexagonal prisms of mica. I met with some felspar crystals nearly three inches in diameter, and these are accompanied by augite, bearing the same proportion to them in size as the ordinary minute grains to the common-sized felspars. In some parts the basis alone is gray, and incloses a vast number of distinct rhomboidal felspars of a reddish colour, which project from the exposed surfaces of the rock by the destruction of the intermediate matter. In general the colour appears to be owing to the dissemination of minute augite; and even in the large felspar crystals which are decidedly tinged with the predominant hue of the rock, there is probably a certain proportion of augitic matter introduced sufficient to produce this effect.

This rock is every where more or less columnar. The columns of the upper part of the bed which caps the hill are rudely formed, and of an enormous size. Lower down they become more regular and smaller. The detached rock forming the Punta della Guardia*, the extreme southern point of the island, is an example of very perfect columns collected into a fascicular group and with a double curvature. Many columns, by exposure to meteoric action, and particularly to the sea-spray, become carious, wasting exactly in the manner, if I may be allowed the comparison, of a decaying tooth. Their coating is of a more durable nature than the interior, so that when once decomposition has worn through this crust on any single point, it advances rapidly in all directions through the inner substance, leaving the shell comparatively whole.

The rock described above is one example of a particular species of felspar-

* See Plate XXIV. fig. 3.

rock, which occurs very frequently among the volcanic districts of Italy. It is always closely related to trachyte, and occasionally assumes, in some of its parts, the mineralogical features of that rock. It is generally, however, distinguished from it by a greater closeness of grain and weight, by its uniformly darker colours, and the compactness and brilliancy of its felspar crystals. It passes on the other hand, by acquiring a scaly texture, great compactness, and a laminar structure, into phonolite (clinkstone); and when the latter character is wanting, into compact felspar. In mineral constitution it is identical with many rocks which have been classed by geologists under one or other of these terms, being composed principally of felspar with a small proportion (never perhaps above 10 per cent) of augite, hornblende, or mica. Its specific gravity ranges from 2·65 to 2·90. To avoid circumlocution, and at the same time distinguish it from those other rocks of the same family, I shall designate it for the present by the name of *graystone**. Its colour is in fact the most constant as well as obvious character of the rock; and, wherever I have observed it, is uniformly of some shade of gray, generally leaden, purplish, or iron gray; even the disseminated felspar crystals usually share more or less in the predominant tint of their basis.

The same rock appears in the Scoglio della Botte, Ventotiene, and San Stefano, amongst the Ponza Isles. It is of very frequent occurrence throughout Ischia. The insulated rock on which the castle is built is a well-known example. It is found in the north-west angle of Procida, in the hill of Cumæ, at Marmorata, in the Monte Olibano, and many other points of the Phlegræan fields, in almost all the Lipari Isles, and among some of the older currents of Ætna. In most of these spots its disposition is obviously that of a lava bed or *current*, and in some the crater whence it issued can still be distinguished.

The massive covering of graystone from which the Montagna della Guardia derives its boss-shaped form, is upwards of 300 feet in thickness. Towards the east it rises in a bluff cliff from a rapidly sloping talus, strewn with enormous blocks that have fallen from above. Where the vertical face of the rock takes off from this inclined plane, a stratum of bright red friable tufa, like coarse brick-dust, crops out from beneath the graystone, and reposes on the white semi-vitreous conglomerate. Here, therefore, is another instance of partial alteration in a conglomerate by contact with a later mass of lava-rock, though in this case the alteration has not proceeded to any degree of fusion or vitrification, as in the instance of the pitchstone beds.

* It is the rock frequently described by Dolomieu and Spallanzani under the name of "*lave à base de roche de corne.*" See "A Classification of Volcanic Rocks." Journal of the Royal Institution, June 1826.

On the south the graystone descends to a lower level*, and sinks beneath the sea in the Punta della Guardia; on either side of this cape it may be seen to lie directly on the semi-vitreous trachytic conglomerate, which here exhibits no appearance of change at the plane of contact; probably because the heated mass having flowed from above down the slope of the hill, cooled superficially as it advanced, and upon reaching this rock did not retain sufficient heat to influence its texture. In fact, this is the habitual conduct of ordinary lava-currents, which are seldom,—it may I believe be said never,—found to produce any alteration of importance in the rocks which they meet with in their descent. It is while the boiling matter is forcing its way from below through the overlying strata which impede its expansion, (as was the case with all the largest kind of dykes and protruded masses of the trap family,) and before it has been enabled to part with the intense caloric that actuates its rise, upon the easy terms afforded by the open atmosphere, that the rocks with which it then comes in contact suffer from its proximity; and this, in a degree determined by their nature, the duration of the contact, the temperature of the lava-mass, and other modifying circumstances.

Westward of the Punta della Guardia, the graystone sends out into the sea another low promontory called the Punta del Fielo, which forms the southern limit of the Chiaja di Luna. Here some strata of loose tufa appear broken through as well as covered by the contiguous rock. These are evidently the prolongation of the strata seen beneath the cap of the hill from the Chiaja di Luna. The whole mass of graystone is continuous, forming but one entire bed, and apparently bearing the same relation to the somewhat basin-shaped concavity occupied by the Harbour of Ponza, as the analogous though smaller rock of the Monte Olibano, near Pozzuoli, to the crater of the Solfatara. In fact, the disposition of the stratified tufa which clothes the principal slopes of this basin,—a much safer criterion than mere form,—points it out as the remnant of a large crater, as was judiciously observed by Dolomieu.

Graystone occurs in no other part of the island.

Palmarola.

The high and rocky islet of Palmarola lies about four miles and a half west of Ponza and in a parallel direction to it. It is scarcely two miles in length, and of a very unequal breadth. Like Ponza, this island seems to have lost

* See Plate XXIV. fig. 3.

much of its original extent. Detached groups of craggy rocks stretch to a considerable distance from both its northern and southern extremities. On the west side rise three or four similar masses, lofty, precipitous, and separated from the main islet. These and the steep cliffs by which it is girt round, exhibit unequivocal signs of the powerful degradation to which it is exposed, particularly on the western shore, from the superior violence of the swell occasioned by the prevailing winds, which blow from that quarter over a vast expanse of open sea. This destroying force tends rapidly to separate the island into two nearly equal parts. The opposite indentations which occur towards the middle of its length, called La Forcina and Il Porto, are indeed already connected by a narrow channel, practicable to small boats, in the formation of which, however, art appears to have assisted nature. On either side of this channel the island rises to a height of from four to five hundred feet, swelling gradually towards the south into a peaked eminence, overhanging a steep cliff of tufa, and situated near what may be supposed the centre of the original area of the island. The northern height forms a steep dome-shaped mass, resembling in its outline the Montagna della Guardia in Ponza. The surface of Palmarola is well wooded, and its appearance, particularly on the western side, extremely romantic and picturesque. It is neither inhabited nor cultivated, and therefore clothed in the unchecked and exuberant vegetation natural to the climate, and fostered by the richness of the soil. The myrtle, dwarf-palm, and wild-figtree spring up with peculiar luxuriance wherever a few feet of rocky ledge afford them sufficient depth of soil; while the cytisus, genista, cistus, and numerous tribes of aromatic herbs, occupy every cleft in the craggy cliffs.

The precipitous shores of this island exhibit the same abrupt and irregular intermixture of the prismatic trachyte and the semi-vitreous conglomerate which has been observed in Ponza. The conglomerate here also, as in Ponza, graduates *in every instance* into dark bottle-green pitchstone, where it comes in contact with the prismatic trachyte. I could not observe any indications of the siliceous trachyte which forms so large a part of the other island. The prismatic trachyte, however, becomes highly siliceous in many parts, and is universally ribboned with a multiplicity of zones of different shades of white, yellow, blue and brown, varying in compactness and in the proportion of silex they contain. These zones are still more constant and remarkable than in the analogous rock of Ponza. Their wavings and contortions on the small as well as on the large scale, resemble those of mica-schist and gneiss. Here also, as in Ponza, there exists every indication of the zones being owing to the rock having been drawn out in their direction while in a half-liquid state,

after a partial separation had taken place of the pure feldspathose part from the mixed siliceous base; the local obstacles, both internal and external, that more or less impeded this motion, were obviously the cause of the irregularities of the laminæ. This species of trachyte composes the greater part of the island and all the insulated rocks around, apparently detached from it by the destruction of the intervening conglomerate, which yields with greater facility to the erosive action of the waves. The columnar division prevails, but the columns are generally larger than those of Ponza. On the north side they present vertical ranges of great magnificence and regularity, running up to a height of from one to two hundred feet. Many of the columns are articulated. The exposure of these mural ranges to the breach of the sea at the north point, has produced several caves of no great depth, but with a striking architectural effect; resembling that of Fingal in Staffa, but having in general a much more lofty entrance. Some detached rocks have by the same process been perforated with arches.

The zones of this rock are unequally affected by the wasting influence of the atmosphere, the loose feldspathose layers decomposing more readily than the others; and this circumstance gives the false appearance of a schistose or laminar structure to the exposed surfaces of the rock. The direction of the zones, which is continuous through a great extent, and seems usually to coincide with that of the bed or dyke itself, cuts the axes of the columns indifferently at every angle. The surface of the rocks, as at Ponza, is of a rusty or bluish brown.

The huge rocky boss that forms the northern extremity of Palmarola, entirely consists of prismatic trachyte. It may be observed to abut at a very high angle upon rocks of a different nature on either side of the island. To the east the supporting rock is the ordinary white conglomerate with fragments of glassy trachyte, which is converted, as usual, into dark green resinous trachyte (pitchstone), the passage taking place, as elsewhere, by imperceptible gradations through a band of reddish yellow semi-resinous trachyte. On the opposite side of the hill fronting the west, the northern rock of prismatic trachyte is separated from another mass *of the same nature,* by an intervening bed, nearly vertical, of a dark coloured pearlstone, from 25 to 30 feet in thickness, which graduates into the latter rock, and appears to be the result of an alteration produced by the contact of the neighbouring trachytic rock, similar and contemporaneous to that effected by the same mass in the conglomerate on the other side of the island.

The prismatic trachyte subjected to this change has lost its columnar division, but preserved its zoned structure; the pearlstone presenting the same

parallel, and often sinuous laminæ, which retain a general parallelism of direction to those of the unchanged rock. The texture of the alternate stripes varies likewise in the pearlstone, the basis of which consists of a compact substance of pearly lustre, and a deep lead-blue colour, breaking into small angular pieces. This is ribboned by numerous thin zones of black enamel (pitchstone) strongly resembling obsidian, having a complete conchoidal fracture, but wanting the acuteness and transparency of the fracture-edges which characterize that mineral. These zones of black pitchstone may be observed to be themselves passing into pearlstone, by inclosing more or less numerous minute spheroids of this substance, identical in colour, texture and lustre, with the broader zones, which consist of an intimate and confused agglomeration of similar globules, and have acquired their semi-lithoidal texture and clearer colour by a *devitrification* of the pitchstone. In the part of the bed lying nearest to the prismatic trachyte, by which the change seems to have been accomplished, the zones are distorted into very irregular and repeated curvatures, and contain large knots and lenticular masses of black glassy pitchstone. This variety of pitchstone is rarely porphyritic. It decomposes superficially, and at the sides of the minute and otherwise imperceptible fissures which intersect the rock at right angles to the plane of the laminæ, into a compact white substance. Hence wherever the fracture has followed these fissures, the pearlstone appears ribboned with white instead of black stripes. This alteration is in some parts not confined to the surface, but affects the whole thickness of the layer of pitchstone, which then resembles a pure white enamel, retaining its conchoidal fracture.

The southern moiety of Palmarola is principally formed of loose stratified conglomerate or *tufa*. Strata of this nature compose in particular a lofty cliff facing the south-east, and extending from the Capo di Vardella to the Punta di Mezzo-giorno. They everywhere repose conformably on the irregular surfaces of the prismatic trachyte and its accompanying semi-vitreous conglomerate. They are of the same character as those of Ponza, consisting principally of triturated pumice, and inclosing, particularly in the lower strata, larger blocks of this substance (the scoriæ of the accompanying trachytes), and a few compacter fragments of the neighbouring rocks. Amongst the latter I found some of an ash-gray pearlstone imbedding numerous crystals of felspar; and others of a similar rock in which the felspar is very brilliant and glassy, the spherolitic globules being irregular, generally hollow, and lined with minute crystals apparently of the same substance, while others closely envelop a single imperfect felspar crystal.

*Zannone.**

I have already adverted to the island of Zannone as lying in the ideal prolongation of Ponza, with which it is connected by a chain of sunk rocks detected by soundings, besides the more obvious ones which rise above the water-level in the same line.

The area of this island is scarcely a mile in its longest dimension, which runs North and South, and half a mile in width. It consists of a ragged longitudinal ridge rising gradually from the southern extremity, and after suffering one abrupt depression from which it recovers immediately, terminating towards the N. at a considerable height in a steep and rocky promontory called Capo Negro. The slopes on either side are covered by low brushwood, and afford occasional pasture to a flock of goats and some cattle belonging to proprietors resident in Ponza.

The geological constitution of this island is singular, since above two thirds of its mass is composed of trachyte, which rests at the North point upon limestone.

The former rock is extremely siliceous, and identical with that of La Gabbia, and the northern portion of Ponza, exhibiting the same intimate mixture of concretionary ramifications having a flinty texture and a more or less porphyritic structure, with white earthy patches. It is associated in the same manner with marbled and brecciated masses assuming a great diversity of textures and colours in the same block. The white porphyritic trachyte with crystals of quartz is, however, the predominant rock; and composes in particular the mass which immediately overlies the limestone of the Capo Negro. The mica which is here abundant, in some parts of the rock has decomposed to a certain depth from the weathered surfaces into a reddish ochre. The felspar is brilliant, and the base extremely siliceous, and of a pure white. This rock is occasionally divided into tangled groups of very regular columns varying in size, but sometimes as small as those of the earthy prismatic trachyte in Ponza. In its general character, however, it presents a singularly rude, shapeless, and craggy outline, and all the external features of burr-stone; the decomposition of the mica and corrosion of the earthy parts, giving a cellular and carious aspect to its superficial parts.

It is possible that some of the columnar groups which I observed on the eastern side of the island may consist of earthy trachyte; but, as the shores of the trachytic portion present few vertical sections of any considerable surface, and are rendered otherwise difficult of access by heaps of enormous

* See Plate XXV. fig. 5 and 6.

detached blocks, which prevent the approach of a boat with any swell except on a few points, it is not easy to put every rock of the island to the test of the hammer. My examination was also limited in time by the rapid approach of a *burrasca,* which drove me hastily back to the port of Ponza for shelter.

The boundary-line of the limestone and superposed trachyte is effectually concealed on either side by a large talus of debris. The limestone is of a bluish gray colour, hard, of semi-crystalline grain, and intersected by numerous veins of calcareous spar, which constitute a large proportion of the mass. I could find no organic remains. It has all the characters of transition limestone, and appears to correspond with that of the Monte Circello, a vast mountainous rock, (once the island of Circe, but now united to the continent by the flat levels of the Pomptine marshes,) which rises exactly opposite Zannone at a distance of 10 miles, and has been described by Brocchi, as differing from the ordinary Apennine limestone, and decidedly transition. The fragment of this rock which forms the Capo Negro in Zannone, exhibits highly inclined strata, directed W. N. W. by E. S. E., and dipping towards the Italian coast *.

The loose blocks which have fallen from this limestone rock towards its junction with the trachyte, and make up the talus by which the line of contact is hidden, differ in character from the rock which forms the extreme point of Capo Negro. Their colour is a dark reddish-gray approaching to black; they are no longer traversed by calcareous spar veins, effervesce with the greatest difficulty, and appear to the lens to consist entirely of a close aggregation of cubical crystals, which are most perfect within the fissures and small cellular cavities that penetrate the rock. There can therefore be little doubt that the limestone has been converted into dolomite to a certain distance from its contact with the overlying trachyte, to the protrusion of which it is difficult not to attribute the elevation of this insulated fragment of a transition formation. The frequent repetition of an analogous circumstance in the Alps, where enormous masses of Alpine limestone are rendered crystalline and penetrated with magnesia by the proximity of augitic basalt, and a secondary granite with which it is associated, may be urged in support of this hypothesis †.

* See Plate XXV. fig. 6.

† In the Tyrol. See "Lettre de M. Leopold de Buch à M. A. de Humboldt, renfermant le Tableau Geologique du Tyrol meridional." I take this opportunity of mentioning that I have been enabled to verify the observations made in this locality by Count Marzari, as to the positive superposition of a true granite to secondary conchyliferous limestone, and a sandstone with gypsum.

The circumstance is most distinctly visible near Predazzo in the Val di Lavis. The upper formation of limestone (which is probably Jura) is converted into coarse granular dolomite re-

Scoglio della Botte,

A peaked insular rock, which has acquired this name from the rude resemblance of its form to a boot, rises above the sea-level at about a third of the distance from Ponza to Ventotiene. It is composed of graystone similar to that of the Montagna della Guardia in the former island; exceedingly compact, hard, and tough, of a coarse crystalline or granitoidal texture; the crystals being almost solely of felspar with a deep purplish gray tinge. The visible crystals of augite are few, small, and imperfect. The mass of the rock is split into rude prismatic blocks. It is superficially coated by a thin pellicle of a blackish colour like a dull and poor varnish, which I conceive to be analogous to the black glazing observed by Humboldt to invest the surface of the granitic rocks of the cataracts of the Orinoco, and apparently produced by long exposure to sun and moisture. Beneath this the rock is remarkably unaffected by decomposition, perhaps because the process of mechanical abrasion by the violence of the waves which break upon it, advances more rapidly than the chemical influence of the atmosphere.

In calm weather the base of this rock may be seen to extend at no great depth below the surface of the water to considerable distances in most directions, but particularly towards the west. There can be little doubt indeed that it is the solitary remnant of a much more extensive mass, and is indebted for preservation to its extreme solidity, without which it must have been long ago swept away by the powerful forces of destruction by which in so exposed a situation it is almost without intermission attacked.

---

*Ventotiene.**

This island is removed considerably to the eastward of the group already described, lying nearly at equal distances from Ponza and Ischia, upon a straight line which may be imagined to connect them. Its area has nearly the form of an acute rectangular triangle; the base, which is about four miles in

---

sembling Carrara marble in aspect. The inferior strata of gypsiferous sandstone and shell limestone (which I conceive to be *new red* and *muschelkalk*) are likewise more or less altered where they approach the granite. This last rock passes into an augitic porphyry (basalt), and on parts into serpentine. The whole mass appears to have broken through these secondary strata from below, elevating them to a great height in massive pyramidal mountains. On the borders of the principal mass of basalt, other smaller dykes traverse the same secondary rocks.

* See Plate XXV. fig. 7.

length, running East and West, and the obtuser angle pointing to the North. The surface has one general slope from the summit of the Capo del Arco, a bluff promontory which forms the acute and western angle to the eastern side, where a small port, almost the only landing place in the island, is excavated from the indurated tufa rock. A cluster of habitations is grouped around it. With the exception of this one point, the island is circumscribed by perpendicular cliffs. Its physical structure is of the simplest character, and corresponds exactly with that of the island of Procida, and of the neighbouring hills which are so closely grouped together in the volcanic district included between Naples, Pozzuoli, Cumæ, and Aversa, and which are generally known to geologists under the name of the Phlegræan fields.

The island consists of parallel and wavy strata of yellow and brownish tufa, resting upon a massive bed of graystone, which rises to a height of more than 300 feet above the sea at the extremity of the Capo del Arco, and sinks gradually towards the east below the water level. Though the remainder of the island exhibits no rock but tufa, this slanting bed is without doubt prolonged beneath it, and supplies the solid foundation of the entire mass. Indeed the graystone which disappears on the south side at less than half its length from the eastern promontory, is visible throughout the whole of the north-western side. This rock is of a dark violet or purplish gray, fine-grained and compact, strikes fire readily with steel, and contains small imbedded crystals of felspar, augite, and mica. The upper part at the Capo del Arco is cellular, and even scoriform at the surface of the bed. The lower is amorphous, or split into massive blocks by irregular fissures, which are evidently but the result of the retreat that accompanied its consolidation. The external surfaces of the rock are exceedingly dark-coloured, almost indeed black; and this sombre colouring together with its harsh forms give an unpleasing and savage effect to the cliff that towers in gloomy majesty above a group of lesser rocks projecting from its foot. The westerly swell, which at the time of my visit forced its way with tremendous roarings into the caverns it has worn in these black, shapeless, and scorified masses, added to the horror of the scene. The fable of the dark dogs that barked round the waist of Scylla appeared to me more appropriate to this promontory than to that less fearful one on the Calabrian coast.

The tufa of Ventotiene is interstratified with *lapillo*, or coarse fragmentary pumice. It is incoherent in the higher parts of the island; but to the east, and particularly wherever it approaches the sea-level, sufficiently indurated to be quarried and shaped for building-stone. The loose strata contain many fragments of granite and sienite, and of a graystone sometimes resembling a

compact felspar or clinkstone. I met also with some pieces of a rock composed of mica and pyroxene alone, identical with many which occur in the conglomerates of Somma. In the lower parts of the island these fragments are partially water-worn.

Throughout the whole extent of Ventotiene the upper strata of tufa are more or less penetrated to a short distance from the surface by a calcareous cement, producing a sort of sandstone, which is disposed in irregular horizontal layers connected by smaller vertical veins. These are often interlaced in a reticulated manner, and occasionally have the figure and structure of stalactites, with a fistular cavity in the centre. A few fragments of shells are observable in this sandstone, but too much broken to allow of their being recognized. Where the volcanic sand predominates over the cement, this stone is hard and solid; where the calcareous matter abounds it is friable. In some parts the grain is fine, and the rock becomes compact, and shows a semi-conchoidal fracture.

These beds appear of very recent origin, and to have resulted from the deposition of calcareous particles by water filtering through strata of loose volcanic sand of different degrees of fineness. But, since the rest of the island is entirely volcanic, from whence are we to suppose the calcareous matter derived? It is difficult to conceive it to originate any where but in the upper bed of vegetable earth through which the rain water percolates, carrying off the substance of the testacea that are undergoing decomposition there. And this hypothesis is corroborated by the remarkable quantity of recent land-shells observable in the stratum of soil wherever it is cut through. Lime is known to exist in a state of combination with the other constituents of volcanic rocks, and consequently of their triturated particles which compose the tufa. From thence we may suppose it taken up by the superficial vegetation, and converted into a carbonate, which is transferred to the mollusca that feed on these plants, and require it for the construction of their shells. The ultimate decomposition of these restores it to the earth, where it enters again into the composition of a mineral mass.

A similar process seems to take place on the sides of Vesuvius, where calcareous stalactites have been observed to form upon the roofs of caves in the lava rocks occurring within the cultivated district of the mountain. The volcanic island of St. Helena presents an analogous formation, which is probably by no means of rare occurrence amongst volcanic districts, though the absence of other sources of calcareous matter is not in all so incontestable.

San Stefano.

East of Ventotiene, and at the distance of rather more than a mile, lies an islet of this name, which is made use of as a depôt for convicts by the Neapolitan government. It is nearly circular, less than half a mile in diameter, and surrounded by steep and craggy cliffs. In structure it resembles Ventotiene, consisting of a single mass of graystone, rising from 150 to 200 feet above the sea, and surmounted by a few strata of loose tufa. The upper part of the rock is exceedingly cellular; the lower has a rude tendency to the columnar configuration. The composition of the rock is similar to the graystone of the larger island.

The surface of San Stefano is deeply indented by two shelving ravines, opening on opposite sides: these I conclude to be the two craters spoken of by Dolomieu. It is, however, probable, that if any crater was originally formed during the protrusion of this mass, the loose and fragmentary parts of its circumference must have been destroyed by the degrading action of the sea. The few conglomerate strata that remain, appear to have moulded themselves on the irregular surface of the bed they rest upon, and are not sufficiently abundant to point out the position of the orifice of production. The proximity of this is, nevertheless, attested by the scoriform character of the graystone rock. A calcareous sandstone similar to that described above in Ventotiene, is found on the surface of this smaller island, and suggests the same observations.

From the above details on the constitution of this group of islands, it will perhaps appear that they afford scope, as was anticipated, for observations of considerable geological interest. It remains therefore to point out the analogies they present to the volcanic formations of other neighbouring countries, and recall the particular facts which tend to elucidate the yet obscure history of these rocks.

In a general view it is impossible to overlook the decided separation of the rocks which compose these islands into two classes, apparently belonging to two different ages (in this locality at least), viz.

1. The trachytes with their accompanying conglomerates; and 2ndly, those rocks, which, without stopping to discuss the question as to their also belonging or not to the family of trachytes, have been mentioned, to avoid present discussion, by the name of *graystone*.

In the island of Ponza, where alone these two classes are found together, they are separated by horizontal strata of tufa, which probably belong to the later rock, since they have been deposited after the subjacent trachytes had suffered a considerable degree of denudation. The graystone is also in every instance accompanied by its peculiar conglomerates.

The first class of rocks bears a decided analogy to some of the trachytic formations of Hungary, so minutely described by M. Beudant, and is perhaps more nearly allied to them than to the more contiguous rocks of the same family in Italy, France, and Germany.

Thus the prismatic trachyte of Ponza corresponds very closely in mineral composition to some varieties of the "trachyte" of the Hungarian groups. It is however clearly distinguished from the predominant rock species of those districts by the total absence of hornblende, which is so frequent and conspicuous an ingredient in the trachytes of Hungary, as occasionally to bring them very near to the characters of basalt. The Ponza trachyte differs also from that of Hungary, as well as from most rocks of this family yet observed, in the regularity and constancy of its prismatic configuration; but this character is of trifling moment in the comparison, since it mainly depends upon adventitious circumstances; the same mass of rock being in many instances found to occur prismatic in one part and amorphous in another.

Another peculiar feature of the Ponza trachyte is its ribboned structure, in which as well as in its constant association with a semi-vitreous conglomerate, it offers some analogy to the *Perlite* of Hungary. After an attentive perusal of the great work of M. Beudant, and an inspection of the collection of specimens brought by him to Paris, no doubt remained on my mind that the zoned structure of the Hungarian perlite (semi-vitreous trachyte) and the lenticular form of its lithoidal parts are owing to the substance of the rock having been drawn out in the direction of the zones while possest of an imperfect fluidity, and after the globular-concretionary separation characteristic of pearlstone, had wholly or in part taken place. The motion was probably owing in this case to the subsidence or flowing of the matter, in obedience to the impulse of its own gravity, down a slightly inclined plane, (since the direction of the zones is universally more or less horizontal,) as was the case with the vitreous lava currents of Lipari, Volcano, Teneriffe, and Iceland *, which are ribboned in the same manner, and pass repeatedly into pearlstone. In Ponza and Palmarola the zones are more frequently vertical than horizontal, and appear to have invariably taken the direction in which the mass was impelled, from

* Currents of obsidian of Von Buch, Sir G. Mackenzie, Dolomieu, &c. &c.

below upwards, through the broken and separated portions of overlying rocks that opposed its expansion.

In all these cases the curvatures and contortions of the stripes are obviously owing to the obstacles, whether internal or from without, by which the uniform progress of the liquid matter was impeded; and principally to the various degrees of mobility of its different layers, those of coarser grain (and particularly the spherolitic concretions,) retarding the motion of the proximate layers which possessed a greater liquidity. The same remark applies with equal force to the similar rocks of the American Cordilleras. These are described by M. de Humboldt as uniformly ribboned, and often to such a degree as to put on the appearance of stratification; as exhibiting a base composed of bluish-gray semi-vitreous globules, closely compacted together, and inclosing parallel zones and lenticular masses of obsidian (Cinapecuaro, Oio del Agua, del Pinal, &c. *); as enveloping fragments of reddish brown trachyte, half-fused, at one extremity of parallel elongated cellular cavities. It is obvious at once how closely these characters correspond to those of the pearlstone of Ponza and Palmarola; and they are explained with the utmost facility by the process which is proved to have given rise to them in the latter case. The last variety of perlite quoted above affords a beautiful illustration of the truth of this theory. It is quite evident that the elongated cells which stretch in parallel lines behind half-fused fragments of felspar (spherolites, in the words of M. de Humboldt, "like the tail of a comet from its nucleus,") were created by the inferior mobility of these coarse fragments to that of the finer enveloping mass, and are analogous to the hollow that forms behind any stationary or resisting body which is plunged into a running stream. These cells therefore are certain indications of the direction in which the mass was moving immediately before its consolidation.

I may remark that the pearlstone of Oyamel (the Mountain of Knives) in Mexico, veined with obsidian, bears a still further analogy to that of Palmarola in the vertical direction of its zones, by which these masses are proved to have been propelled from below in the manner of dykes.

It may be mentioned that some varieties of the *porphyre molaire* of M. Beudant, as far as can be distinguished from the specimens I have had the opportunity of seeing, are identical with the siliceous parts of the prismatic trachyte of Ponza. The similar varieties that occur in the island of Ischia have been already adverted to.

The siliceous trachyte of the Ponza group must be conceived to correspond

* Essai Geognostique, &c. pp. 341, 342.

to the "porphyre trachytique avec quartz" of Hungary, in its porphyritic character, compactness, quartzose nature, and the chalcedony that lines its cavities. Its veins of nearly pure quartz, groups of amethystine crystals, and the brecciated aspect of its flinty parts, bring it nearer to the *porphyre molaire* of that country. M. Beudant, indeed, mentions these two species of trachyte as passing mutually into one another, and therefore, as in Ponza, mere varieties of the same rock. Lastly, the overlying conglomerate strata of Ponza and Palmarola, almost entirely composed of triturated pumice, correspond both in situation and nature to the "conglomerats ponceux" of the Hungarian groups.

Little analogy exists between the rocks of the Ponza isles and the trachytic mountains of central France, beyond an occasional rather close similitude of mineral composition, and those other points of resemblance that necessarily arise from their common volcanic character.

The trachyte of the latter district is disposed for the most part in vast beds dipping gradually away on all sides from a common centre of eruption; and alternating horizontally with one another, with varieties of basalt and greystone, and with their conglomerates, which latter are in no way altered at the surfaces of contact; while the analogous rocks of the Ponza group occur in irregular dyke-shaped masses, which interfere with and interrupt their conglomerates in the most arbitrary and irregular manner, at the same time constantly effecting a change in their texture to a certain depth from the plane of contact. These differences will be satisfactorily accounted for by the reflection that the latter formation is evidently of *submarine* origin, while the trachytes of France, which are superposed to a primitive platform averaging 2,800 feet above the sea, and rise themselves to more than double that elevation, must, in all probability, have proceeded from volcanic vents acting under the pressure of the atmosphere alone.

The other trachytic formations of Italy are so little known, that it would be almost useless to bring them forward as objects of comparison; and indeed from their inland situation the examination of their structure is attended with all the difficulties noticed in the commencement of this paper. It may be mentioned, however, that the two groups of the Monti Cimini and Monte Amiata appear to agree with those of France in the characters of disposition, and therefore differ in this respect from the Ponza rocks, which they resemble only imperfectly in mineral constitution. The trachytes of the Euganean Hills and of La Tolfa, on the contrary, show themselves, like those of the islands in question, in enormous vertical masses breaking through older formations, which in the last-quoted instance is a transition limestone similar to

that of Zannone. The pitchstone dykes of the former locality, and the highly siliceous rocks which accompany the aluminite of the latter, are additional features of resemblance to the Ponza formation.

But independently of the analogies which may be traced in them to other districts, the trachytes of the Ponza group present circumstances of great interest in a geological view, from their novelty and anomalous nature.

The principal of these it may be worth while to recapitulate. They are,

1. The extremely regular and constant columnar division of an earthy trachyte.

2. Its ribboned structure, and the gradations which prove this character to arise from the linear extension of the mass while in a state of imperfect liquidity, coupled with a concretionary process. In fact, in this rock it is easy to trace the operation of three distinct and consecutive processes, to which it was subjected in the following order: viz. 1st. The concretionary arrangement of its constituent minerals into spherolites of felspar imbedded in an impure and partly siliceous base. 2ndly. The movement of the mass by protrusion from below, accompanied by the tumefaction, elongation, and finally the confusion and attenuation of the felspar globules, by the production of porous parts, and the fracture and envelopment of some external portions which consolidated more rapidly than the rest. 3rdly. The separation into columns. Upon reflection it will perhaps appear that these observations are of a nature to explain many of the most remarkable features of some trap-rocks, such as the zoned and schistose structure of clinkstone ; and may even illustrate the similar appearances of elongation and contortion so frequent in gneiss and micaslate.

3. The peculiar disposition of this rock ; from which it appears to have repeatedly broken through superincumbent beds both of semi-vitreous conglomerate, and of older trachyte ; with which it alternates in irregular and more or less vertical beds, almost in the manner of the alternations of different varieties of trap with conglomerate rocks in the transition series.

4. The conversion of the rocks thus cut through, *both conglomerates and trachytes,* to a greater or less depth from the planes of contact, into *pitchstone,* generally porphyritic and passing both into pearlstone and obsidian ;—a fact which may serve to throw some light on the hitherto obscure history of this remarkable rock. In fact, the pitchstone of Ponza and Palmarola is thus proved to be only a modification of trachyte, effected by a more or less incomplete fusion under considerable pressure and friction ; and appears to be pro-

duced by this process indifferently from both a trachytic conglomerate, and a solid rock of the same mineral constitution.

These localities, however, do not alone furnish observations of this kind. I could instance various spots in the vicinity of Naples and the isles of Procida and Lipari, in which strata of pitchstone, porphyritic and occasionally with the structure of pearlstone, intervene between intruded beds or dykes of feldspathose lava-rocks and their accompanying conglomerates, graduating into both.

Rocks differing in mineral constitution when submitted to the circumstances under which this modification takes place, will of course produce different species of pitchstone. Thus in Ponza and Palmarola this substance varies with the varying character of the rocks into which it graduates; perhaps even more than might have been expected from the great similarity of mineral composition in the unchanged rocks. All are obviously varieties of *resinous* or semi-vitrified *trachyte*.

The pitchstone of Hungary, according to M. Beudant, passes by repeated and easy gradations both into his *perlite* (semi-vitreous trachyte), and into a compact lithoidal felspar rock resembling the "porphyre trachytique" and "porphyre molaire."

The pitchstone of the Cantal is derived from a clinkstone (slaty trachyte). That of Egg appears to be basaltic, graduating into that rock. The pitchstone of the valley of Tribitsch in Saxony repeatedly passes into a compact porphyritic felspar, described by M. Beudant as mineralogically identical with varieties of the Hungarian trachytes. At Grantola, which I visited in 1821, this substance intervenes between a felspar porphyry and overlying strata of old red sandstone, and blends imperceptibly with both these rocks. The pitchstones of Scotland are said to occur almost invariably in veins. This situation is easily reconciled to the idea of the fusion of the congenerous rock beneath some overlying bed, which must be split by the expansion accompanying this process, and its fissures occupied by the liquid matter, under such circumstances of pressure and friction as seem requisite for the production of the peculiar texture of pitchstone.

5. The siliceous trachyte of Ponza, La Gabbia, and Zannone, is of considerable interest; since, though the existence of quartz as a constituent mineral in trachyte is no longer a fact of such rare occurrence as it was once supposed, yet in no instance that I am acquainted with, has it been found to enter so largely into the composition of the rock. Even the *porphyre molaire* of Hungary is far less siliceous than the analogous rock in Ponza. There are two causes, to either of which a hasty decision might refer this abundance of quartz: viz. 1st. Infiltrations of water impregnated with siliceous matter; and

2ndly. That class of changes which volcanic rocks are often observed to undergo from exposure to the action of sulphureous vapours. I am inclined to believe that the first of these processes may have partially modified the local disposition of the siliceous matter, taking it up from one point, and depositing it perhaps in a more perfectly crystallized and purer form on another; and this particularly in the case of the brecciated varieties. But the siliceous base of the white porphyritic trachyte and its numerous imbedded crystals of quartz, can never be accounted for by the supposition of infiltration: and the parts of a different texture or structure must be presumed to have derived their abundance of silex from the same source as this, in the absence of proofs to the contrary. On the other hand, there are many circumstances which discountenance the notion that these rocks have been subject to decomposition by acid vapours. Such are their general weight and density; the uniformly siliceous nature of the whole mass, (whereas in altered lavas this character is confined to the immediate limits of the *fumarole* or fissures by which the vapour escapes); the dispersion of numerous grains of quartz through the base of the rock wherever it puts on a porphyritic character; the non-existence of aluminite, which must necessarily have been produced by the union of the sulphuric acid with the alumine of the rock; and lastly, the frequent brilliancy of the inclosed crystals of felspar and mica. It is true that these minerals are occasionally altered, the first into a kaolin, the last into an ochrey powder: but it is probable that this change is principally owing to meteoric influence; and at all events, since it is exactly in the compactest and most siliceous parts of the rock that these imbedded crystals are the most brilliant, it is obvious that the predominance of silex cannot be referred to subsequent alteration. We must therefore conclude that this character belonged to the original constitution of the rock at the period of its production.

6. The brecciated aspect of parts of this rock, as well as of the prismatic trachyte, is important from the analogy it exhibits to the occasional pseudo-brecciated structure of the serpentines, the older porphyries, and granite. This appearance is here evidently owing to those parts of the mass which consolidated first having been broken up by the continuance or renewal of its motion, and their fragments enveloped in the part which still remained liquid. Similar instances of this brecciform structure are to be seen on other points of the volcanic district of Italy; as for example, in a rock of graystone lava between Lacco and Casamicciole in the island of Ischia, and again on the S. E. flank of the rock of Cumæ. A close inspection of these and other rocks of an analogous character, leads to the conclusion that a concretionary separation of the constituent minerals influenced by the forces of affinity, often assisted

in producing this pseudo-conglomerate structure; and indeed it may be conceived without difficulty, that should such a process take place before the motion of the mass had entirely subsided, or a renewal of motion occur during the action of the elective process, the concreted parts, offering an impediment to the motion of the surrounding liquid, would be broken up and enveloped in such a manner as to participate more or less in the double character of nodular concretions and imbedded fragments.

7. The occurrence of a vertical vein of cupriferous iron pyrites in the siliceous trachyte, having many characters in common with ordinary metalliferous veins, such as the association of the ore with black clay and quartz crystals, is a fact which would have been more striking a few years back, before it had been recognized that trachyte is frequently the matrix of the richest metals; as for example, of the gold of Villalpando in Mexico, of Konigsberg and Telkebanya in Hungary, &c. In the present case the ore appears to have been produced by sublimation, since it penetrates the sides of the fissure and the included fragments, exactly in the manner of the specular iron so common in the clefts of volcanic rocks. The quartz crystals are of contemporaneous formation.

In Ponza the trachytic formation is separated from the incumbent rock which has been designated as *graystone*, by strata of loose conglomerate, chiefly composed of pumice, and which may belong in part to both the under and overlying formations, since their disposition in the Chiaja di Luna proves them to have been deposited at two different periods. In Palmarola the stratified tufa must be supposed to belong to the trachyte, since in this island graystone is wanting.

The mineralogical characters by which this last rock (graystone) distinguishes itself from the subjacent trachyte have been already sufficiently enumerated. Its frequent occurrence in Ischia, Procida, and the volcanic district round Naples, has been also mentioned; and in the Scoglio della Botte and the islands Ventotiene and San Stefano, we see a series of similar rocks geographically connecting these localities with that of the Montagna della Guardia in Ponza. The huge mass of graystone of this mountain, resting at a great height upon stratified tufa on that face of the hill which overlooks the basin of the harbour, and on the other side following the inclination of these strata in a rapid descent below the level of the sea, has precisely the figure and disposition of a lava-current.

The bed of graystone which forms the substratum of Ventotiene has even more decidedly the form and aspect of a mass which has flowed down an in-

clined plane in a state of imperfect fluidity. The Capo del Arco is the source of this current, its superior elevation and the scorified nature of its rocks attesting the proximity of the orifice of production. Whatever accumulations of ejected matter may once have been formed to the west of this cape, may naturally be supposed to have disappeared under the erosive attacks of the sea, whose waves continue still to degrade even the solid lava-rock. The fragmentary ejections that fell on the surface of the graystone bed, remain there in the form of conglomerate strata (or tufa), which, as far as I could observe, present no indications of having been deposited below the sea-level. The effect of rain-torrents would be sufficient to give them that occasionally waved disposition and alluvial aspect, as well as their partial induration.

The mass of graystone of San Stefano, though not so decidedly current-shaped as that of the neighbouring island, gives occasion to the same remarks. That of La Botte is reduced to too small a remnant to offer in its figure any indication of its mode of production.

On the whole, it is worthy of remark, that while the different graystone rocks of this group of islands have the general form and disposition of lava-currents, the subjacent trachytes are on the contrary disposed in a manner wholly different from that of any known body of lava produced by a supra-marine volcano. If we reflect on the rare occurrence of such circumstances as are necessary to the obtaining a view of the internal structure of a trachytic formation, elevated by volcanic action from subaqueous vents, we shall be able to appreciate the opportunity afforded in the Ponza group. At the same time it must not be forgotten that the destroying process which has laid open the constitution of these islands to our observation, has without doubt robbed them of a very large portion of their original mass, and, in all probability, of by far the greater part of the fragmentary products by which they were originally enveloped.

In conclusion it may be as well to offer a few remarks on the connection of the Ponza group with the other congenerous formations of the Italian coast. The respective positions of the points on which the volcanic force has developed itself with the greatest intensity, will be perceived at once from the accompanying map*. The relations of mineral character between the rocks produced from these different vents are in general extremely close.

The island of Ischia marks the site of one of the main sources through which a vast quantity of feldspathose lavas have been disgorged, mostly of the

* See Plate XXIII.

nature of graystone; while others, consisting almost solely of felspar, have every right that can be derived from mineral composition to the denomination of *trachyte**. Both species are accompanied by tufas containing much pumice. Ischia is by means of Procida in almost immediate contact with the Phlegræan fields of Pozzuoli and Naples, where upwards of thirty deformed craters, thrown up by submarine eruptions upon a shallow coast, are still distinguishable within a small space. The lavas of this district are chiefly graystone; but some, as for example that of Astroni and the Monte Olibano, are unquestionably trachytic.

Further on rises the insulated cone of Somma and Vesuvius, which originally appears to have produced the same class of rocks, while its later lavas are solely of a basalt, in which leucite entirely replaces the felspar, from the elements of which it is probably in part composed. Some obscure deposits of feldspathose rocks, with their associated tufas, appear at intervals within the recesses of the eastern shore of the bay, as far as the Punta di Campanella. Southward of this cape no traces of volcanic formations exist, I believe, nearer than the Lipari Isles.

Towards the North, the hilly group of La Rocca Monfina, rising above Sessa and Teano, attests another powerful source of volcanic action. Like

* The term *trachyte* was invented by Haüy, and subsequently adopted by Daubuisson, Brongniart, Brochant, &c., to designate a rock of peculiar mineralogical characters. An attempt has since been made, probably through inadvertence, by M. de Beudant, and after him by M. de Humboldt, to limit the name, thus appropriated, to rocks under particular circumstances of geognostical position, these authors refusing the appellation to rocks identical in mineral composition with those to which they apply it, when they occur in the form of lava-currents, or cover their conglomerates or tertiary formations. This restriction of a purely mineralogical term is not only unwarrantable, according to all the legitimate principles of nomenclature; but is certainly founded on mistake, since a large proportion of the very rocks which are brought forward by these writers as types of their trachytic formation, overlie their own conglomerates, as well as basalt, and freshwater and tertiary limestones, and frequently occur in the form of lava-currents; —*ex. gr.* in the Mont Dor, Cantal, Euganean Hills, Mont Amiata, Monti Cimini, Teneriffe, Leeward Isles, &c. &c.

In fact, just as granite, gneiss, porphyry, and serpentine, are denominations purely relating to mineralogical character, and as such equally applicable to the oldest as to the most recent of these rocks, so must the terms Trachyte and Basalt be allowed to remain independent of all question as to age or geognostical relations. It is obvious that the determination of the mineral nature of a rock must precede any attempt to find its place in the geological series (since it is only by these characters that it can be distinguished from or compared with the other rocks with which it is associated). The *primary* name must therefore be purely mineralogical; and if the appellations of trachyte and basalt are absolutely to be confined to a geological meaning, it behoves the authors who make this change to substitute in their room some other primary names, which may serve to designate rocks of their peculiar character in whatever situation they may be found.

that of Somma, this vent appears first to have given rise to numerous currents of feldspathose rocks, which were succeeded by leucitic lavas.

The detached points on which eruptions appear to have taken place, though in no great number, within the wide longitudinal valley of the Garigliano, viz. at the Rocca d'Evandro, and in the vicinity of Pofi, Veroli, Frosinone, and Tichiena, connect the volcanic district of the Terra di Lavoro with that of the Campagna di Roma. The lavas produced by these mouths are almost solely augitic. Those of the great volcanic group of the Monte Albano are on the contrary leucitic, the leucite being frequently associated with and occasionally replaced by melilite. North of Rome another series of volcanic vents commences, in which a still closer association of the feldspathose and leucitic lavas is observable. These fall without the limits of the map.

The intervals that separate the volcanic groups of the Terra di Lavoro are occupied by plains of stratified tufa, which appear to have been originally redeemed from the sea, when at a higher comparative level than at present, by the accumulation of the fragmentary matters thrown up by the neighbouring vents, and distributed pretty evenly upon its shores and bottom. These conglomerates, composed of comminuted pumice, seem to have been drifted to a considerable distance up the valleys of the Apennine chain that open into the plain of Campania, at the time when this massive limestone ridge formed the coast of the Mediterranean. This circumstance confirms the opinion that the earliest productions of the volcanos of this district were of feldspathose nature. These stratified tufas must be supposed to extend beneath the space actually occupied by the sea as far at least as the groups of Ischia, Ventotiene, and Ponza, to which they were probably in part indebted for their origin. Deposits of an analogous nature appear on various points of the valley of the Garigliano and on the southern foot of the mountains of the Volsci, bordering on the Pomptine marshes. Others again constitute the undulating plain of the Campagna di Roma covering strata of tertiary marl and sandstone. In all these localities they of course share in the mineral constitution of the lavas produced contemporaneously with them from the neighbouring volcanos.

The extensive tract of the Pomptine marshes themselves, has in all probability a general substratum of this nature, since it crops out superficially on all the higher ground of this swampy expanse, and has been also observed in the lower parts wherever excavations have been carried to any depth*. Here it is covered by local formations of marl and peat, but chiefly by vast alluvial deposits of sand thrown up by the action of the sea, which have already connected the once insular rock of Circe with the main land, and still continue to

* Brocchi, *Catalogo Ragionato*, p. 78, 79.

elevate and gradually leave dry the shelving shore of the coast between Terracina and Ostia. This sand, whether taken from the actual shore, or from the interior of the Pomptine marshes, where it extends almost as far as Cisterna, is found to be composed of grains of reddish flint, of milk quartz, and of amethystine quartz, with a few fragments of felspar crystals and grains of magnetic iron. This composition shows it to proceed from the harder detritus of the Ponza isles, or at least of the submarine rocks of the same nature with which they are doubtless connected.

Thus while the violent sweep of the south-westerly swell is engaged continually in degrading and eating away the already skeleton forms of these exposed rocks, their water-worn fragments are drifted onwards by the same force, and thrown up on the shore of the neighbouring continent, which gains in extent of surface even more rapidly than the islands lose. It is thus that the great law of organic nature exhibits itself with equal force in the mineral kingdom; the destruction of one formation giving rise to the production of another.

It might appear like an omission were I to terminate this paper without a word upon the ages of the formations which have been described in it. I am of opinion that most of our notions on the absolute age of the pyrogenous rocks must be necessarily of a vague, uncertain, and hypothetical character. Whatever doubts may exist as to the exact manner in which many of these rocks have been produced on the surface of the globe, still enough is known and generally recognized concerning the phænomena in which they originate, to show that with them the collocation of similar beds is no proof of their contemporaneous production. In the sedimental and arenaceous rocks, we infer the age of a whole stratum or series of strata from the observed geological relations of one of their parts, notwithstanding the solutions of continuity or the concealment of intervening portions, that may separate this from the remaining mass. But amongst volcanic rocks we know that by the side of a mass of early date, one of recent formation may be produced tomorrow, exactly similar to the former in mineral composition. And in reality the natural tendency of the volcanic phænomena is by no means to produce vast and extensive formations at a single epoch; but on the contrary, to form partial masses, one by one, at very distant intervals of time, which yet often agree most closely in their mineralogical characters*.

* This is a consideration too much overlooked by some late authors, who, assuming the contemporaneous formation of whole districts of trachyte or basalt, have inferred their place in the geological series by the observed relations of one or two isolated members.

In the case under consideration, if we assume that the graystone of Ponza, Ventotiene, and San Stefano, belongs to the same period, which their nearly equal state of preservation seems to authorize, (and perhaps the analogous formations of Procida, Ischia, and the Phlegræan fields may be referred to the same age,) the superposition of this rock in Ponza to the trachyte, which shows signs of previous degradation, will warrant the inference that the latter rock is of very early date. Its connection with the transition limestone in Zannone conveys no information as to its age, and the conclusion that might appear to follow from the absence of any intervening secondary or tertiary strata, is destroyed by the fact that they are equally wanting above the trachyte.

The question therefore as to the absolute age of this trachyte is involved in complete obscurity.

XV. *Observations on the Structure of the Border Country of Salop and North Wales; and of some detached Groups of Transition Rocks in the Midland Counties.*

By the Rev. JAMES YATES, M.A. F.G.S.

[Read March 4th and 18th, 1825.]

Of the rocks which occupy the confines of Shropshire and North Wales, lying between the slate mountains on the West, and the extensive formations of limestone, red sandstone, marl, and gravel, on the East, it may be observed generally, that they are very various in their character, and differ exceedingly in their thickness, their induration, and their colour. They are sometimes earthy and amorphous, and at other times crystalline, in their structure. They have sometimes the appearance of mechanical, sometimes of chemical deposits, and sometimes these appearances are united in the same rock. In their composition, they pass from argillaceous to siliceous, and from siliceous to calcareous; but the prevailing earth appears to be clay, the next in quantity is silica, and carbonate of lime appears to be by much the least abundant of the three. It may also be remarked, that these strata are of moderate thickness, never perhaps exceeding 6 feet in depth, and varying from that to the state of mere partings between one bed and another. The harder strata are commonly separated by thinner beds of soft clay, and often divide, in consequence of a kind of rude crystallization, into angular or rhomboidal pieces. All these circumstances produce in them a manifest tendency to disintegration. They are generally conformable in their position, and most commonly dip towards the East; but occasionally they exhibit remarkable contortions. They rise with a gentle inclination, and usually terminate towards the West in abrupt escarpments, while the Eastern slopes of the hills, which they constitute, correspond evenly with the surfaces of the strata underneath. They are intersected also by tortuous valleys, which sometimes expand from the condition of narrow wooded glens into level plains of great fertility. Of the mountainous portions of this tract none perhaps are higher than 1500

feet above the level of the sea. Various kinds of trap-rocks rise through them in great masses, and are distinguished by their abrupt and rounded summits.

Passing from these general observations, we may endeavour to illustrate the nature of the strata under review by the detail of their appearances in particular places. This may be best done by pursuing the section of the different rocks across their basset edges.

1. To begin from the North and proceed gradually Southwards, the line of section, which first claims attention, is in the vicinity of Vale Crucis. The lofty Oernant Mountain rises above the northern boundary of the valley of the Dee, and contains a large slate quarry, belonging to Sir W. W. Wynne. Here the strata are curved with extraordinary regularity into the form of concentric circles, the cleavages of the rock having also the appearance of radii, in consequence of being perpendicular to the direction of the strata. These circumstances are deserving of notice, not only as exhibiting a fine specimen of curvature, but as showing the primitive character of the rock.

At the distance of about 2 miles to the N. E. is presented the perpendicular face of the rocks of Edlw-y-seg. These are part of the edge of the great basin of limestone, containing the coal formation of North Wales Their direction is generally from East to West, but in a waving course, and through a tract of many miles in length. A steep talus of debris covers about two thirds of their height; and above this their face rises almost perpendicularly, presenting a remarkable specimen of regular stratification, and a striking contrast to the forms of the slate mountains in their vicinity. The divisions of the strata of limestone are rendered conspicuous at a distance by beds of black bituminous shale, which lie between them. This shale is for the most part perfectly soft and friable; it is, however, frequently indurated by the addition of calcareous matter, and thus passes into fœtid limestone. It is also sometimes mixed with a large proportion of sand, and then resembles very much the mud deposited in the estuaries of the Dee and Mersey.

These cliffs contain various shells and corals, usually considered as belonging to the mountain limestone of England. In the case of shells occurring in the limestone beds, the matter of the shells is generally removed, only casts remaining, or newer depositions of calcareous spar in place of the original substance. But in the beds of shale the testaceous matter seems to be preserved with very little alteration in its texture or composition. In a formation of so great antiquity in the geological history of the globe, this circumstance

appears not a little curious and interesting. The softness of the shale in which they are imbedded, also contributes to render these specimens of fossil shells remarkably perfect, the muscular impressions and interior structure of the larger terebratulæ being exhibited with great distinctness.

The valley situated between the Craigs of Eglw-y-seg and the Oernant Mountain, contains hills of moderate elevation. Their superior fertility and beauty, the lively red colour of the ploughed fields, and the rounded masses of red conglomerate scattered among the debris of the limestone, prepare the geological traveller to expect a rock such as that of which they consist, and which is hard, highly ferruginous, stratified, tending to slaty, and composed of grains and small pebbles of the older rocks united by an argillaceous cement. This rock is therefore a variety of the grauwacke of the continental geologists. Its extent is very limited. Nearer Llangollen and about the steep hill of Dinas Bran, we find only the common appearances of the beds of shale, slate, and slaty sandstone, about to be described as occupying by far the greater part of the region under our review *.

2. The next section which I shall attempt to describe, is represented by a line drawn from Oswestry westward to Llansilin. Such a line crosses, within the space of 5 miles, the basset edges of all the strata from the new red sandstone to the slate.

After quitting the level ground about Oswestry, which consists of gravel, clay, and sand, and covers beds of coal, we come to the strata which dip under the coal, and belong to the millstone grit formation. These strata form several successive ridges, which rise higher and higher as we advance towards the west. The eastern slope of each ridge appears to correspond with considerable exactness to the plane of the strata beneath it, although these strata are overspread with gravel, clay, and sand. The western slope is steeper, cutting across the outcrop of the strata. On the summit of one of these ridges, at the distance of 2 miles from Oswestry, is the race-course, commanding an extensive view of the rounded slate mountains of Wales on the west, and of the plain of Shropshire to the east. Besides the Wrekin and the other hills, which encompass this plain to the south and east, another

* It may here be remarked, that at the entrance of the Vale of Llangollen the rocks on each side are limestone, and that the lower beds are bituminous, and highly fetid when rubbed or struck. They contain shells of the Productus Scoticus of Sowerby, (tab. 69. fig. 3.) which he had received from the limestone of the great coal formation in Scotland, and which was found also by Mr. Henslow in the Isle of Man. (Geol. Trans. vol. v. p 493.) Their stratification is exceedingly regular, the beds being about 8 inches in thickness.

series of hills meets the eye, which is more interesting to the geological observer, though of inferior elevation. For, as he stands upon the verge of strata dipping east, he sees the hills alluded to dipping in different directions according to the order of their arrangement, so as to form the basin, which contains the coal field, situated on the confines of Shropshire and North Wales. These hills are, 1st, those of Ness-cliff, whose escarpment is towards the South-east; then Greensill; near it the Cleve, which rises with an even slope terminated by a most distinct escarpment towards the east; and lastly the two ridges of Hawkstone, one to the north of the other. Thus the strata of these hills together with those on which the spectator is situated, are seen to converge so as to form a basin for the deposits of coal; and they consequently suggest to him the supposition, that as the rocks beneath his feet belong to the millstone grit formation, those in the series of hills so connected with them may probably belong to the same class of strata.

The ridge, on the summit of which the race-course is situated, has a very precipitous escarpment. Along its base flows a small river, called the Cynlleth, and the grounds of Llanvorda, the residence of Mr. Henry Wynne, occupy that part of it which lies to the south of the race-course. This escarpment displays in regular succession the strata of the millstone grit formation. The uppermost are found to consist of hornstone, which varies in its colour and texture, sometimes becoming very fine and passing into perfect flint. It divides by its cleavages into rhomboidal pieces, and has evidently supplied many of the pebbles, both angular and rounded, which abound in the gravel between this ridge and Oswestry. Below these strata is a bed, several feet thick, of white sandstone. It consists of grains almost entirely siliceous, which are for the most part cemented into a firm rock by a siliceous deposition: but in many situations the texture of this sandstone is more loose and friable. In some places it is spotted throughout its substance with black and brown oxide of iron; in others it contains the hollow impressions of entrochi. We then come to a remarkable bed of indurated clay, generally of an ochre yellow colour, though sometimes passing into bluish or brownish black. It is light, and adheres to the tongue.

Below this are successive beds of sandstone, the thickness of which far exceeds that of the upper beds, and sometimes amounts to several yards. Some of them contain contemporaneous veins of silica, which are very conspicuous by their projection on surfaces exposed to the weather. Sometimes the sides of these veins are exposed instead of their cross fracture. In these cases they are striated like slickensides, but certainly not from the effect of

friction. The upper beds are still white, and somewhat approaching to chert. Those underneath become ferruginous, and contain a few impressions of entrochi and of curved cylindrical forms apparently of vegetable origin *. The lowest bed, which is also the thickest, and far exceeds the others in the height of its precipices and the size of its detached fragments, is of a dark red colour, its grains of sand slightly cohering and glittering in the sun. This rock descends to the river, which flows at the base of the escarpment, and also dips under it from the opposite slope of the valley. Its broken and precipitous faces are sometimes reduced by the action of the weather into the form of irregularly rounded masses, and at other times are streaked by the projecting lines of the harder siliceous veins. Pursuing the course of the river from Llanvorda towards its head, we find beds of limestone rising from beneath the sandstone.

The direct road from Oswestry to Llansilin leaves the spot now described at the distance of about a mile to the north. It crosses similar beds, which are extended over a greater space, because accompanied by no escarpment so high and precipitious as that of Llanvorda. We first come to these beds after passing Offa's Dyke about two miles from Oswestry. They are found through the space of about two miles further along the sides of the road, and in quarries and weather-worn cliffs. They appear to dip uniformly under one another, with an inclination of about 30° to the horizon. The white cherty beds are succeeded by a dark red sandstone, analogous to that which forms the base of the escarpment at Llanvorda. Pebbles of quartz are disseminated through it; the summit of a considerable hill on the left hand of the road called Mynydd Moel, consists of this sandstone. Its exposed cliffs are worn into irregularly rounded masses, and resemble the usual appearances of the red sandstone of Lancashire, Cheshire, and Shropshire. On advancing westwards we next come to a bed which lies under the red sandstone, and consists of grains and small pebbles of quartz with a few pebbles of slate and joints of encrinites, rather loosely aggregated by a calcareous cement. Limestone of the same gray colour with the cement of this conglomerate immediately succeeds; it abounds in corals, encrinites, and shells; large quarries are worked in it on each side of the road: it contains numerous veins, often an inch or more in thickness, of the red sulphate of barytes. Towards the east it slopes gradually with a dip conformable to that of the calcareous breccia and the sandstones lying over it; whereas on the western side, looking to-

* I am informed that bodies of the same kind are found in the red sandstone at Manchester and its vicinity.

wards the mountainous country of Wales, it terminates in perpendicular precipices; it contains beds of soft crumbling shale, and is evidently to be regarded as a continuation of the interrupted chain of the limestone of Eglw-y-seg. Among the corallines of these strata is a madrepore, bunches of which are seen on the upper surfaces of the beds of limestone along this ridge, evidently in the same position in which they originally grew. The limestone, which now penetrates and envelops them, has been deposited without removing them from their places, or even materially altering their form. I have observed the same curious phænomenon in the ridge of mountain limestone which rises over the strata of Brecon Forest in South Wales; and I am informed by an accurate observer (Mr. Underwood), that he has seen it in the same formation at Plasnewydd in Anglesea, and on the opposite side of the Menai.

On advancing westward, so as to surmount the ridge of limestone, the eye is impressed by the immediate change in the character of the scenery, from that of long ridges of moderate elevation to the appearance of huge mountains divided by valleys of corresponding dimensions. Between these two kinds of scenery the wall of limestone forms a line of demarcation. The strata, which dip under the limestone, and constitute mountains 1500 feet in height, consist of numerous beds of a slaty micaceous sandstone, dividing by natural separations into rhomboids of a micaceous clay-slate, and of a soft shale. These beds are very numerous, and various in their thickness; but in general the rhomboidal kind is conspicuous among the others, in consequence of the even vertical surfaces presented by its broken strata. It seems to be the same rock with the rhomboidal killas of Devonshire and Cornwall, which Dr. Berger has denominated Common Grauwacke *.

Besides the stratified rocks now described as lying under the limestone, a mass of porphyritic greenstone presents itself at Glascoed near Llansilin in five or six considerable hills, which are distinguished by their abrupt rounded forms, rising like irregular knobs among the stratified rocks, and covered with gorse and coarse grass. The strata of limestone appear more inclined where they lie upon the greenstone, but do not show marks of disturbance.

3. I shall now attempt some account of the rocks which occur in the direction of the road from Welchpool to Ludlow, containing the country intermediate between the limestone ridge already described and that of Wenlock Edge. The whole of this tract is principally occupied by strata of the slaty micaceous sandstone, dividing into rhomboidal pieces and alternating with

* Geol. Trans. vol. i. p. 112.

shale, which has been mentioned as lying beneath the limestone at Llansilin; but sometimes a crystalline siliceous deposition occurs, and at intervals unstratified masses of trap present themselves. These, together with the remains of organic bodies, will claim our chief attention.

An example of the siliceous deposition is seen to advantage in the park near Powis Castle in the immediate vicinity of Welchpool. It occurs in strata dipping towards the north-west at an angle varying from 45° to 70°, and forms a long ridge with an abrupt escarpment. The strata are not separated by planes, but have a waved and swelling superficies. When broken, they divide into pieces having sharp edges and angles, and triangular or trapezoidal surfaces. In many places the rock becomes very red; in others it is little or not at all coloured with iron; masses and thin beds of clay are found among the strata. From the clayey and ferruginous portions the soil of the park is probably derived; it is fertile, and abounds with fine trees: these circumstances all show the identity of this rock with that so often noticed at Bromsgrove Lickey near Birmingham; in this, however, the imbedded grains of sand are larger than in the Lickey quartz-rock. At both these places the siliceous rock contains impressions of the various shells, corals, &c. which are found in the limestone. In some cases the cavities so impressed have been filled again by a subsequent deposition of calcareous spar, which also forms veins in the rock and entirely penetrates its substance.

Half a mile from Welchpool on the west of that town are large quarries of greenstone worked in the side of an eminence called Standard Hill. The principal cleavages of the rock are nearly vertical in parallel planes 10 or 12 yards asunder. By other cleavages, subordinate to these and perpendicular to their planes, it is divided into columns, which lie in a nearly horizontal position and approach to regular prismatic figures. The colour of the rock is in general a light green, sometimes marked with white specks; it contains small portions of anthracite and carbonate of lime. In a part separated from the rest only by one of the great vertical cleavages, it approaches much nearer to the usual appearance of the trap rocks of Great Britain, being harder, of a dark colour, and containing disseminated grains of iron pyrites.

A grauwacke slate alternating with beds of shale, which forms the ridge of Rallt at a little distance to the north, and great part of the long mountain on the east, is found also at the base of Standard Hill; between it and the greenstone there occurs a dyke or large vein, consisting of rounded pebbles and angular fragments of the contiguous rocks cemented by limestone; each pebble or fragment is surrounded by a coating of white calcareous spar: this dyke of breccia is nearly vertical, and several yards in thickness.

The Breidden group, not far from Welchpool, consists chiefly of various kinds of trap rocks, some of which contain globules of dark brown calcareous spar, crystallized occasionally in diverging radii, and probably derived from the fusion of small fragments of limestone. Sometimes instead of containing globules of spar, the rock contains small angular fragments of limestone.

Trap, similar to that of Standard Hill, occurs again in a hill on the left of the road from Welchpool to Montgomery, immediately to the east of Offa's Dyke. The trap rises in an abrupt and almost square mass above the verge of the hill; it has the remains of a small fortification on its summit, and is called Nant Cribba Moat, being encompassed by a trench. It contains considerable quarries; it is divided like the Standard Rock near Welchpool, by a vertical structure of separation. Large veins of breccia pass through the rock in directions parallel to its great planes of separation, and resemble that of the Standard Rock, except that here the base is trap, and not limestone.

Another large and conspicuous mass of trap is the site of Montgomery Castle; it consists almost entirely of a base of felspar. The trap of Montgomery, like that of Nant Cribba and Welchpool, includes veins of breccia, and also of calcareous spar with coal.

A variety of shale or slate-clay is seen in immediate contact with the trap at Montgomery, and occurs at intervals through the whole extent of country from that place to Bishop's Castle. This slate-clay easily crumbles down on exposure to the weather; it has a conchoidal fracture, and divides into flattened nodules like those of clay-ironstone, and it is remarkably like the slate-clay usually found in connection with clay-ironstone and coal. It passes into the rhomboidal grauwacke slate occurring in the whole surrounding region.

Corndon Hill rises, at the distance of some miles to the north-east, to the height of 1700 feet above the sea, and contains the *flag-stone*, which is only a variety of this rhomboidal grauwacke slate, and which abounds in the Forest of Brecon and other parts of South Wales. Corndon also rises exactly like the hills in that district, to a sharp edge, with an escarpment towards the lofty mountainous region.

At the village of Norbury, about four miles north of Bishop's Castle, and at the southern extremity of the Stiperstones, we find a siliceous in connection with a calcareous deposition. The siliceous portion is a gray quartz with a splintery fracture, and somewhat crystalline, dividing into irregular rhomboids and tetrahedrons. In a quarry on the western side of the village the stratification of this rock is distinctly seen, and a large proportion of its beds is full of cavities derived from the testaceous parts of different animals. The casts are chiefly those of a pentamerus, of the turbinated madreporite of Parkinson,

and of a flat fan-shaped bivalve, seen also in the indurated clay of Llanvorda. A few casts of nautilites, entrochi, and trilobites, also present themselves. Veins of sulphate of barytes pass through the rock, and transparent crystals of the same substance extend into many of the cavities formed by the removal of the shells; the same cavities contain portions of the black oxyd of manganese, sometimes in minute botryoidal concretions, and sometimes diffused over the surface of the quartz in dendritical delineations, and also minute fasciculi of silky crystals of malachite. It ought to be remarked further, that although the rock is full of cavities where it is contiguous to the seams and fissures of its strata, yet the substance of the shells generally remains, and the rock is perfectly solid in the inner parts of its rhomboidal distinct concretions.

After leaving Norbury, as we proceed northwards for at least seven or eight miles, we again find the slaty sandstone in regular strata: its colour is a deep dull red; it contains shining particles of mica deposited conformably to the planes of stratification. It is not crystalline, but consists of minute grains of sand, imbedded in a compact, hard, and very ferruginous clay; the surfaces of its fragments are irregularly triangular or trapezoidal. If the usually received order of superposition be applicable to this portion of the strata of England, we have here in its proper place the old red sandstone. But, confining ourselves to facts, we do not perceive that this rock differs essentially from the micaceous slaty sandstone, or schistose grauwacke, which has been so often mentioned as occurring through this region, and which geologists have also called Transition Slate *.

The Stiperstones Mountain is a long and steep ridge situated to the west of the tract of the red schistose sandstone just described; its direction is N. and S., and along its summit are seen large weather-worn masses of a cherty sandstone and of a siliceous conglomerate. Both of these rocks have the characters of the strata belonging to the millstone grit formation; the masses of cherty sandsone have a distinct stratification, the planes of which are now nearly vertical, proving them, notwithstanding their singular position along the ridge of a lofty hill, to be the displaced fragments of a more ancient and regular formation. At the bottom of this mountain and near its north-western extremity is situated the Snailbach lead-mine, which is worked in the slate, and is described by Mr. Arthur Aikin in the fourth volume of the Geological Transactions. A few miles further north rises Pontesford Hill, terminating

* In Scotland the strata, which are seen about Lanark, at Cartlane Craigs, and the Falls of Clyde, correspond with those in the district of Shropshire described in the present paper.

on its north-eastern side by an almost perpendicular precipice, and said to consist of trap rocks.

On the "higher" road from Bishop's Castle to Ludlow, and near the limestone range of Wenlock Edge, is situated Long Lane Quarry, at a little distance above "the Craven Arms." The rock is a fine sandstone, occurring in strata of considerable thickness, and used in all the surrounding country for building: it occurs also in the form of large thick flag-stones; its colour is a greenish gray; it contains portions passing like veins through its substance, which are of a rusty brown colour, and are full of the cavities formed by small terebratulæ and other shells, the matter of which has been removed. These brown veins chiefly accompany the divisions of the strata, and the cleavages perpendicular to them. The shells have been more thickly deposited in their substance than in the rest of the rock; the greenish portion of the rock effervesces abundantly in muriatic acid; it may be called a calciferous sandstone. Small particles of malachite and iron may be observed intermixed with the sand, and probably the colour of the rock may be attributed to the presence of these metals: the various appearances may be explained by supposing the carbonate of lime to have been deposited from a state of solution in the same fluid, which contained the granular and sandy portions mechanically suspended. This fluid must have contained also the shells found in the rock, and would deposit them in the greatest abundance in situations contiguous to the present surfaces of the successive strata. After the consolidation of the calciferous sandstone thus produced, another fluid must have penetrated it by following the course of the divisions of its strata and of its cleavages; this fluid must be conceived to have been a solvent of carbonate of lime, and to have removed, as far as it penetrated, both the substance of the shells and the calcareous portion of the sandstone, at the same time altering the colouring matter. The strata of Long Lane Quarry dip to the S.E. at an angle of about 20° to the horizon; if continuous, they must dip under the limestone of Wenlock Edge. The same rock, sometimes more siliceous and argillaceous and sometimes more calcareous, occupies all the country as far as the vicinity of Ludlow.

The rock to the west of Ludlow, in the picturesque grounds of Downton Castle, is of the same kind with that on which Ludlow Castle stands, and which is also exhibited in large quarries opposite the Castle. The cliffs which overhang the Tame in this demesne, are in many cases divided in the direction of their natural joints or cleavages into the same rhomboidal forms which have so often been noticed. In other cases the effect of atmospheric decomposition has been to exhibit great oval masses in the midst of the shattered fragments

of the rock. Where this rock is quarried, the recent openings are commonly marked by its great conchoidal fracture; and the same principle of aggregation which produces this kind of fracture, produces also the forms of the concentric lamellar concretions elicited under the influence of slow decomposition.

Immediately above Downton Castle, Mochtre Hill rises to the N., its strata dipping towards the river Tame. Along its ridge are quarries of limestone: in one of them, called Weaver's Quarry, the upper strata are thin beds of shale with calciferous sandstone in nodular masses, forming irregular strata between the beds of shale: the limestone lies conformably to the beds above it in strata of very considerable thickness.

The most curious and one of the most frequent fossils of this vicinity is the Pentamerus Knightii, (figured in Sowerby's Mineral Conchology, Pl. 28.) a different species of the same extraordinary shell, which has been noticed in the quarries at Norbury. The shell consists of fibres perpendicular to the plane of the substance which they compose. The septum, which divides the shell longitudinally into two parts, has a natural parting down the middle. Its two portions are contiguous below, but divide above so as to inclose a small longitudinal cavity. The connection of the septum with the external curvature of the shell is very remarkable. The fibres of the septum being perpendicular to its plane, meet at right angles the fibres of the curved exterior portion. They do not intermix, but terminate upon a plane, which bisects the right angle formed where the septum meets the exterior curvature both above and below. The shells have a tendency to separate both in the direction of these small planes, and of the broader plane, which divides the septum into its two parts. The fibrous structure, which has now been described, resembles that in the bone of the cuttle-fish, the fossil mytilus, &c.

4. A fourth district, respecting which I shall now notice some particulars, is the country in the vicinity of Church Stretton. The "transition, or newest primitive clay-slate," as it is denominated by Mr. A. Aikin, constitutes the mass of the Long Mountain, which fills up the greater part of the space between the line of section just traced, and the region on which we now enter: it shows itself on the western border of the town of Church Stretton; it is here highly inclined, and much contorted; its beds are thin, passing into a soft shale; but it includes beds of a harder and coarser schist, and in all its general characters corresponds with the appearances of the country about Llansilin and other places already described. In contemplating the hills on the other side of the town and of the Watling Street, which passes by its

eastern border, we seem to be amidst the vast ruins of a former world: In Caer Caradoc, the most celebrated of these hills, we may trace two great dykes of stratified clay-stone. They rise in numerous ragged precipices above the summit of the hill, and in their forms, though not in their mineralogical qualities, they resemble the before-mentioned fragments of inverted strata, which crown the Stiperstones.

At the bottom of Caer Caradoc and at its N. E. extremity we find again the same quartz-rock as that of Bromsgrove Lickey, in nearly vertical strata. From a crystalline state it passes into that of a coarse sandstone, the grains of which are rather loosely aggregated; a vein of trap, about 12 inches thick, passes through the sandstone.

In ascending Lawley Hill above the village of Comely, we again find the quartz-rock near the base of its southern declivity. An excavation has discovered in it an irregular space filled with quartz-pebbles and sand, which are rather loosely cemented with clay. This inclosed mass is divided into angular concretions, with a siliceous cement bounding each concretion, and entering more or less into its substance. We may suppose that the sand and pebbles were first united by a loose cement of clay, and that, as the clay hardened, the entire mass formed itself into its separate concretions; the clay having prevented the free entrance of fluids, the interior of the concretions is devoid of any subsequent addition. But the fluid which contained the siliceous matter of the adjoining quartz-rock has penetrated between the concretions, and for some depth into them. The surfaces of the concretions sometimes exhibit the striated appearance of the slickensides of Devonshire and Cornwall, which has been commonly attributed to the supposed sliding of one mass of rock over another; but in the case before us, and in that already noticed at Llanvorda, the striæ are evidently the result of crystallization.

The quartz-rock both here and at the base of Caer Caradoc, contains small portions of malachite, and indeed this substance characterizes the rock wherever I have found it. Ascending Lawley Hill, at a situation higher than the quartz-rock, we again meet with the trap, containing, as on the opposite declivity of Caer Caradoc, globular concretions of radiated epidote.

Lawley extends from north to south in a narrow ridge, which may be regarded as a continuation of that of Caer Caradoc. The two extremities of the ridge have a slight, though very perceptible convergence towards the west; thus the hill assumes something of a crescent form, which may be observed in like manner in most of the trap hills of this region: on the east it is encompassed by a valley of considerable depth, which is terminated by a sharp ridge, somewhat tortuous in its course, and consisting of a fine white crystal-

line sandstone in strata nearly vertical, and in masses, often of great size, scattered over the broken edges of the strata and the declivity of the ridge. At some distance further east is another ridge, nearly parallel to the former, and separated by a second valley; it consists of a slaty sandstone resembling some of the varieties of grauwacke already described, and dips eastward at an angle of rather less than 30° to the horizon. Still further eastward, but in a direction towards the south, a third siliceous ridge commences, which is called the End Hill of Hope Bowdler; its northern extremity is an abrupt cliff, from which it extends southwards about a quarter of a mile; it consists of a straight chain of extremely rugged barren eminences of quartz-rock, in nearly vertical strata. At the distance of several miles to the south, and at the other extremity of Hope Bowdler, we find a coarse serpentine, containing grains of sand. Still further southward a considerable quarry is worked in strata resembling those of Ludlow and Downton. The strata are nearly horizontal; in the lower part of the quarry they are a yard or more in thickness, and when broken, show most distinctly the great conchoidal fracture: and their natural separation, according to their cleavage, is into square or rhomboidal pieces with sharp angles.

The hilly country of slate and trap terminates about a mile to the north of Church Stretton. We here stand upon the verge of an extensive plain varied only by swelling knolls of clay and gravel. But on coming within two miles of Shrewsbury, we cross a ridge of trap, which is intersected by veins of schist resembling that at Church Stretton. This ridge is called Baseton Hill, and ranges through a considerable space from N. E. to S.W.

I now proceed to give some account of the detached portions of rocks, which are of the same nature with those already described.

1. The first detached district, which I shall notice, is the vicinity of Bewdley. A remarkable trap-dyke is situated a short distance to the north of that town. The Earl of Mount-Norris, through whose estate it passes, has traced it along a straight line of 4 miles in length and in a direction nearly from N. N. E. to S. S.W. It probably extends still further towards Enville in Staffordshire and the forest of Wyre in Shropshire. At Shatterford it crosses the turnpike road from Kidderminster to Bridgenorth, and is accompanied by a bed of coal and by thin broken beds of the usual sandstone of coal-formations, all in a vertical position. It crosses the Severn nearly 2 miles above Bewdley, and occasions a considerable fall in the water, which the bargemen surmount by steering through a gap in the dyke. On the lower side of the water this dyke presents to it a vertical face 16 feet in depth, the

sandstone being washed away. It consists of a compact greenstone, similar to those which usually accompany coal-formations. The beds of coal and sandstone and of clay, having the same valuable properties with the Stourbridge clay, extend towards the S.W. in the direction of the dyke, and probably join the coal-formation at the north-western base of the Abberley Hills. The district so occupied is bounded by strata of red sandstone, which rises in picturesque precipices on each side of the Severn at Bewdley, and extends from Kidderminster to the trap-dyke at Shatterford; by beds of limestone, which appear towards the south-west at Burnthorn and Abberley; and by a dyke of white sandstone, which runs for some miles parallel to the trap-dyke, and terminates the coal-formation towards the north-west.

2. Not more than 10 miles to the east of Bewdley are situated the Clent Hills, distinguished by the names of the Proper Clent Hill, and Walton Hill. Hagley Park rises upon the north-western declivity of Clent Hill, the ridge of which is separated by a deep valley from Walton Hill. A branch of the latter ridge, named Calcut Hill, extends still further towards the S.E. in the direction of Bromsgrove Lickey. This cluster of hills is distinguished by its steep slopes, which give to it the characters of romantic beauty. The rock consists for the most part of the red sandstone, which occupies the whole surrounding country as far as Stourport, Bewdley, Enville, and Stourbridge. At a quarry behind "Thomson's Seat" in Hagley Park, beds of calcareous breccia occur in the red sandstone. They sometimes consist of grains of quartz, decomposing felspar, and limestone; and sometimes of larger pebbles of the same substances, though principally of encrinal limestone. They are highly ferruginous, their cement consisting of the red oxyd of iron intermixed with clay, and the whole mass being further hardened by the infiltration of carbonate of lime, which is going on even at the present day. The upper part of Clent Hill consists of a trap-rock, commonly so much decomposed as to form a complete covering of soil, but occasionally appearing in harder fragments, which have resisted the action of the elements. This trap might come under the denomination of grauwacke, as its cement appears to be principally argillaceous, and it is full of small grains of quartz, felspar, and other minerals. But it has not a schistose structure, and does not exhibit any distinct marks of stratification. Walton Hill consists of a porphyritic and sometimes amygdaloidal trap, very much decomposed. The solid rock is not any where visible. But the soil, penetrating to the depth of two or three feet from the surface, and abounding in angular fragments of porphyritic trap, which is also scattered over the hill and is seen in some openings, where it

appears to have lain always undisturbed, sufficiently proves that the whole mass of the hill has consisted of this rock. Calcut Hill, which is much lower than the others, is covered with beds of clay, sand, and gravel, and its whole surface is cultivated.

3. The detached portions of the older rocks, which are found in the vicinity of Dudley, may be traced to the distance of about three miles from the Clent Hills. Mr. Keir's account of them, in Shaw's History of Staffordshire, renders it unnecessary to attempt more than a supplementary account of some of the most remarkable appearances, which have been brought to light since he wrote.

A line drawn from Wolverhampton to Rowley will coincide with the general direction of the chain of hills, which forms the south-western boundary of the South Staffordshire coal-field. The Birmingham canal pursues a serpentine course from Oldbury through this coal-field, the length of which is parallel to the same line. The chain of hills commences rather more than a mile to the south of Wolverhampton, and terminates a little beyond Rowley. All its principal eminences are from 300 to 400 feet above the level of the Birmingham canal. The town of Dudley is situated about half-way between the two extremities of the chain, which at this point is also divided into two portions of the most opposite mineralogical characters.

The northern portion is calcareous. It consists of four hills separated by transverse valleys; all very long in proportion to their breadth; and corresponding in their general direction to the line which has been indicated. The Beacon Hill near Sedgley differs from those further south in yielding lime, which is not only used for building and for agricultural purposes, but also possesses the quality of setting under water. The three hills further south are called Hurst Hill, the Wren's Nest, and the Castle Hill. The two latter are perforated by great artificial excavations. Mr. Downing of Dudley, who superintends the extensive operations carried on in these hills, has favoured me with a very exact transverse section of the Wren's Nest on a scale of 80 yards to an inch *.

* See Pl. XXVI. fig. 3. AB is a tunnel cut through the hill from east to west on the same level with the Birmingham canal, and consequently coinciding with the general level of the adjoining country. It crosses four strata of limestone, marked 1, 2, 3, 4, which form with it angles, varying, as shown on the section, from 45° to 79°, but converging towards the summit of the hill. The parts of the hill intermediate between these strata consist of a bluish slate-clay, charged with calcareous matter, and including concretionary masses of argillaceous limestone with grains of copper pyrites. These varieties of the calcareous strata, not being used to burn into lime, are here known by the name of *bavin*. They converge, as well as the strata of good limestone, towards the summit of the hill, and about the middle point of the tunnel they form a perfect

Since Mr. Keir published his description of the South Staffordshire Coal-field, including a particular account of his own colliery at Tividale, he sunk there a shaft (named Pit N° 11), 55 yards in depth, after which he came to a solid rock of greenstone similar to that of the adjoining hills. The shaft was continued through it to the depth of 35 yards. The workmen then came to coal 4 yards thick, which they described to be in the state of cinders. This pit is at a considerable distance from the base of the Rowley Hills, and on the further side of the road to Oldbury, between it and the Birmingham canal. The other pits in the same colliery are situated towards the south, between N° 11 and the Rowley Hills, and also towards the west and north, but in none of them was greenstone found. If, therefore, this mass of greenstone communicates with the Rowley Hills, it is probably in a direction towards the S. E. Greenstone has been found in the same manner more than two miles from the Rowley Hills at "Moat Colliery," and at Mr. Finch's colliery near West Bromwich.

Since the publication of Mr. Keir's account, coal has been got further eastward, and the result is of some importance in the geology of this district. Shafts have been sunk in the Square Field Colliery near the Swan at West

---

arch. The hill is about half a mile long. The three strata of limestone, (marked 2, 3, 4,) which lie towards the west, meet at the southern extremity of the hill, inclosing it with a very uniform curvature; while the stratum (marked 1,) which lies nearest to the eastern verge of the hill, bears towards the Castle Hill on the south. All these strata make a smaller angle with the horizon in proportion as they approach the same part, and seem at length to dip under the adjoining transverse valley. At the northern extremity of the hill, they are diverted from their course, their continuity being broken. All of them incline from this point towards the N.W. and form a ridge, which, though a continuation of the Wren's Nest, is of inferior elevation, and is called Mon's Hill. The beds of limestone, which mantle round the interior of bavin, rise on each side above the general level of the hill, so that their projecting edges inclose a valley on its summit. The dotted portions of these strata show in the section the parts, which have been removed in the process of mining by open work. The greatest mass has been taken from the western side of the hill, where the removal of the dotted part C D has exposed to the day the highly inclined face of a bed of *bavin*, full of shells, corallines, entrochi, and trilobites. The inner strata of limestone (marked 2, 3,) are each 11 yards in thickness; the outer, (marked 1, 4,) 8 yards. The thickness of the bavin between the strata (1 and 2) on the eastern side of the hill, nearly corresponds with its thickness between those on the western side. The section of the Castle Hill discovers four strata of limestone, approaching to a vertical position, converging towards the middle of the hill, and almost exactly corresponding in thickness, and in their relation to the interposed bavin, with the strata of the Wren's Nest. All these circumstances conspire to prove, that the strata have been elevated from a position nearly horizontal; and there seems sufficient ground for the inference, that the mass of greenstone, which forms the remainder of the chain of hills towards the south, is continued northwards under the elevated strata of limestone.

Bromwich. In the Pits N° 1, the *Broach Coal* is 60 yards from the surface and about 1 yard thick. 56 yards lower is the *Main Coal*, which is, as usual, 10 yards thick. The dip of the strata in this and some adjoining collieries is towards the north-west, and amounts to 3 or 4 inches in the yard. The fact thus ascertained respecting the dip of the strata in this situation is subversive of the argument for the imagined extension of the coal eastward under the red sandstone, which has been founded upon a comparison of the dip of the strata at the base of the Dudley Hills with their dip in the Warwickshire coal-field near Atherstone and Nuneaton.

Besides the chain of hills which I have already described, another may be traced of a similar character, though of very inferior elevation. It is not continuous, and in most places it is very much altered by decomposition. The indications of its existence, which I have observed, are as follows. Barrow Hill is situated more than half-way from Dudley to King's Swinford on the right hand of the road. Its interior has been in a great measure worked out, and now presents extensive and picturesque excavations. It consists of greenstone, resembling that of Salisbury Craigs, very fine-grained, and containing small crystals of augite. This is accompanied by basalt, which, from its lustre, resembles the Arran pitchstone, but differs from it in being softer, and in yielding a gray streak, and a black, but not porous enamel. The greenstone also includes irregularly-formed globular masses of variously coloured wacke, and veins of calcareous spar, both rhomboidal and fibrous, with quartz, hornstone, and sulphate of barytes in long six-sided tables.

The hilly cultivated ground extending from Barrow Hill to Brierly Hill seems to be of the same formation. At Brierly Hill the greenstone is distinctly seen by the road side near the chapel. Pursuing the line of these hills across some lower ground, we come to a stratified mass of limestone of the same nature with that of the Dudley Hills. It occurs at a place called "the Hayes" in the hamlet of Lye Waste, and forms a narrow broken ridge of small extent, rising very abruptly from beneath successive beds of slate-clay, coal, clay containing balls of ironstone, and a friable substance abounding in pebbles of quartz-rock of various sizes, which seems to be a decomposed greenstone. This substance forms a gritty soil, distinguished by specks of a dirty white and others of a greenish gray, and it may be traced from the Cradley toll-bar to the Lye Waste*. Near the last-mentioned place it incloses pebbles of

* Beds of trap-tuff are found along the course of the river Stour at Overend near Cradley, and the whole country between Overend and the Lye Waste probably belongs to the trap formation. The same rock rises from under the red sandstone on the declivity of the hill to the east of Halesowen, between that place and Belle Vue.

quartz-rock like that of Bromsgrove Lickey, for which it is quarried as a gravel-pit. When struck with a hammer, it falls in flakes from the sides of the pit, the pebbles dividing by cleavages, which coincide with the surfaces of the flakes of greenstone. To the south of this tract of decomposed greenstone, about Oldenhall, Foxcote, Prescot, and Wollescote, we find sandstones resembling those of coal-formations, and containing the remains of ferns and of trees petrified by calcareous infiltration. The line, along which the greenstone may be thus traced, is parallel to the general direction of the chain of hills before described, and 2 or 3 miles apart from it. The coal-formation, which lies between, is usually considered as a part of the South Staffordshire coal-field, but is separated from it by the Rowley Hills*.

About 2 miles south of Oldbury, and the S.E. termination of the Rowley

* A collection of saline springs upon Pensnet Chace in this minor coal-field, has lately obtained some celebrity as a resort for invalids. Four of the springs have been analysed by Mr. J. T. Cooper of Lambeth, who has thus stated the gaseous and saline ingredients of the well, in which the springs unite. A wine pint contains

Carbonic Acid	2.1 cubic inches
Azote	.4
Muriate of Soda . .	49.75 grains
——— Lime . .	19.07
——— Magnesia .	7.50
——— Iron . .	0.13
Carbonate of Lime . .	1.50
——— Magnesia	1.70
——— Iron . .	.90
	80.55

This water goes by the name of Ladywood Spa, or Cradley Salt Well. A spring of water, probably containing the same ingredients, occurs in a coal-mine at Brierley Hill; and another, which appears to be nearly saturated, in a coal-mine on Cradley Heath in the parish of Rowley, belonging to the British Iron Company. In the gravel to the west of Brierley Hill, the stones are sometimes found to be impregnated with salt. All these springs are situated nearly in the direction of a straight line, running E. and W. across the coal-field, and coinciding with the position of a fault, through which the brine probably rises from the strata beneath the coal-formation. The Moira Bath near Ashby-de-la-Zouch seems to be similarly circumstanced. Its contents are the same with the Pensnet Spa, except that they are without iron. The water is there obtained by means of a shaft 200 yards deep, and rises from beneath the coal measures.

At a place called Windmill End, between the salt springs and the Rowley Hills, a coal-mine has been worked, in which, at about 130 yards from the surface, a stratum of coal was found 14 yards in thickness, but in a vertical position. A fault adjoins this mine on the side next to the Rowley Hills; and in the same situation a rock of conglomerate or calcareous breccia occurs near the base of the hills.

Hills, we find a ridge of coarse conglomerate, called Barnford Hill. It extends about a quarter of a mile in a direction nearly N. and S. Its western declivity is very abrupt, and faces the hills and the village of Rowley. The strata rise towards this side at a high angle, their inclination to the horizon decreasing as they pass eastward. The ridge terminates towards the south in red sandstone near Brand Hall. Towards the north the same conglomerate is seen in the bed of the brook at Oldbury; and the principal head of this stream, called the Lady Well, is remarkably clear and copious like the springs of limestone countries. The pebbles of the Barnford Hill conglomerate consist chiefly of encrinal limestone. With these are intermixed pebbles of quartz and hornstone. The pebbles are sometimes seen impressing their forms on one another, so as to raise the suspicion that some of them have at a former period become soft, although their hardness is now restored. Some of the limestone pebbles are carious on their surfaces, showing that their substance has been partially dissolved. The cement of the pebbles is sometimes calcareous spar, and sometimes a sandstone containing clay together with carbonate of lime; and this sandstone often presents itself lying in thick masses in the midst of the conglomerate rock.

About 5 miles from Birmingham, near the road to Walsall a petrifying spring has been observed, probably originating in beds of calcareous breccia similar to those of Barnford Hill and Hagley Park.

It is further deserving of record, that the proprietors of the Park Field Colliery at Wednesbury, a district where the main coal disappears, and the fundamental limestone was presumed also to have a tendency to crop out, have recently come to regular beds of limestone at the depth of more than 100 feet after sinking through the usual coal beds and a coarse grit underneath them. The highest bed of this limestone, which is of a bluish colour, contains much clay and abounds in producti and terebratulæ.

4. *The Bromsgrove Lickey* presents one of the most interesting examples of the older rocks rising in a detached mass through the red sandstone, and has long attracted the attention of geologists. I offer the following remarks as supplementary to Professor Buckland's paper in the 5th volume of the Geological Transactions. Omitting the small deposits of coal and the recent beds of clay and gravel, the strata composing this range are of three kinds; the red sandstone, the limestone, and the quartz-rock.

The red sandstone incircles the others, and occupies by far the greater part of the country through an extent of 20 or 30 miles on every side. Its stratification is very even, and nearly horizontal. It is seen remarkably well at Tardebig, 3 miles south of the Lickey, both in a quarry and at the en-

trance into a tunnel of the canal, and also in the road, which leads through the hamlet of Burcot. Its general appearance corresponds with that of the red sandstone already described at Llanvorda, Bewdley, and other places. An account of its appearances at Droitwich more especially, is given by Mr. Leonard Horner in Geol. Trans. vol. ii. p. 95.

In a quarry near the N.E. extremity of the lower Lickey range, the red sandstone is highly ferruginous, and contains small masses of an impure hematite. It is here worked for making lime, as it includes in great abundance grains and small water-worn pebbles of limestone. It thus passes into a calcareous breccia, and in this state it is found a few miles to the north near Frankley Church. Its grains and pebbles are frequently united by a calcareous cement.

The limestone of Bromsgrove Lickey rises immediately from under the red sandstone. I was not able to discover it at the southern extremity of the range; but I remarked, as an indication of its presence either now or heretofore, an abundant growth in that particular spot of the Clinopodium vulgare. Some beds with a copious intermixture of sand appear on the eastern border of the range, to the south of the Birmingham road: and at Colmore's Farm, situated on the N.E. declivity, a bed of pure limestone is worked about 2 feet in thickness and 8 feet from the surface of the ground. A red stiff marl lies over it, and beneath it is a similar marl variegated with blue.

At a short distance to the east of this limestone, and at the base of a hill called Leach Heath, a shaft has been sunk to the depth of 125 yards by Mr. Attwood, the proprietor of the estate. The beds near the surface are indicative of a coal formation, consisting of slate-clay, sandstone, coal, and ironstone, a considerable portion of the last being in the state of a red oxyd. Beds of limestone alternating with strata of slate-clay succeed, extending to the depth of above 100 yards from the surface. The limestone appears to be exactly analogous to that of Shropshire, containing shells belonging to the genera Pentamerus*, Terebratula, Productus, &c. with the same coralloids and trilobite, which occur also in the Dudley limestone. The beds of slate-clay, which alternate with the limestone, are remarkable for containing the impressions not only of shells, but of plants apparently belonging to some description of fucus, which has been very much branched, with its frond flat and without a rib†.

The quartz-rock of Bromsgrove Lickey, constituting the lowest portion of

* The pentamerus appears to be not Pentamerus Knightii, but the smaller species found at Norbury.

† See Pl. XXVII. fig. 1, 2.

its strata, passes from the state of a coarse friable sandstone to that of an aggregation of minute but perfectly regular siliceous crystals. The coarse friable sandstone, reddened with oxyd of iron, and having an intermixture of clay, occurs at the southern extremity of Leach Heath. In the greater part of the range the sandy particles, instead of thus loosely cohering, are imbedded in a pure quartz, the fracture of which is highly splendent and vitreous. This rock is consequently very hard. Its usual colour is a smoke gray. Besides the particles of sand, it contains white specks of decomposing felspar, with scattered grains of malachite and of brown hematite. Its strata are marked by the same curved swelling surfaces, which were noticed in Powis Park near Welchpool. By its numerous cleavages, crossing the direction of its strata, it is divided into irregular trapezoidal masses: but its fragments are occasionally found approaching to the more exact rhomboidal forms of common grauwacke. Its strata are sometimes separated by thin beds of clay, which are either of a light green colour, or more commonly of a deep red. Sometimes these seams of clay are unctuous to the touch, and occasionally they pass into steatite. Some portions of the hills, though of rare occurrence, consist of worn angular fragments of the quartz-rock imbedded in a cement, which is softer and more argillaceous, but which belongs to the same formation and is of the same general nature with the whole mass of the hills. The numerous quarries throughout the range afford good opportunities of seeing its stratification, which varies exceedingly in its direction, being sometimes nearly horizontal, sometimes vertical, and frequently more or less curved. A remarkable example of the curvature of the strata was exhibited a few years since in a quarry near the S. E. extremity of the range beside the road to Tardebig. The strata were here seen covering a globular mass of soft micaceous shale, unctuous to the touch, highly ferruginous, and with its laminæ conformable to the stratification of the incumbent quartz-rock. Through a thickness of two or three feet the quartz-rock was ferruginous, very compact, and of the same deep red colour with the shale, thus passing into the state of the grauwacke of the region to the westward. Fig. 4. of Pl. XXVII. is designed to show the position of the strata at this spot, and the mass of dark red micaceous shale, on which they were incumbent.

The compact quartz-rock, which has now been described, forms the great mass of the lower Lickey range. Its crystalline structure is often more or less apparent, and shows, that while its particles of sand, &c. were mechanically suspended, the siliceous base, in which they are imbedded, must have been in a state of solution in the same fluid. But the most complete proofs of this fact are presented in that portion of the range which has been already men-

tioned under the name of Leach Heath. The strata in this part principally consist of an aggregation of siliceous crystals, rather loosely united by a cement of clay; which is sometimes deeply reddened with oxyd of iron. The crystals are never more than a line in length, but as perfectly formed as is commonly the case in large crystals of the same substance. Their form is that of six-sided prisms terminated by six-sided pyramids. The transverse striæ on the sides of the prisms are clearly discernible by the aid of the microscope. These strata abound in fossil impressions of great delicacy, exhibiting the forms of the Dudley trilobite, of the porpital madreporite of Parkinson, of the joints of an actinocrinites, and of the same shells, which occur in the associated limestone. Among these the impressions of the pentamerus are especially interesting as showing the cavities derived from the septa, by which that genus is so remarkably distinguished. Fragments, exhibiting these particulars, are strewed over the summit of the hill and over its eastern declivity, and in the same situation there has been found a considerable quantity of the common ore of manganese. Under the beds of limestone, which have been already mentioned as occurring at the eastern base of this hill, and at a depth of more than 100 yards from the surface, Mr. Attwood in sinking his shaft came to beds of the quartz-rock, abounding in the same fossil impressions and alternating with beds of a micaceous slate-clay. Many of the beds of this quartz-rock, like that nearer the summit of the hill, consist of an aggregation of minute siliceous crystals; other beds are fine-grained and slaty, more nearly resembling common sandstones. The micaceous shale, or slate-clay, is for the most part of a deep red colour from the presence of oxyd of iron, and frequently the quartz-rock in its vicinity partakes of the same character, or, according to the miner's phrase, "runs red."

The red micaceous shale, which has now been mentioned as occurring between the beds of quartz-rock, presents the same vegetable impressions, resembling Fuci, which were before noticed as occurring in the slate-clay of the superincumbent limestone.

5. We now pass to a very interesting range of hills, which in their general characters resemble the Lickey range, but are more extensive, more varied in their component parts, and more illustrative of the connection of these detached masses with the general stratification of England. These hills constitute a diminutive, but very regular mountain chain, extending from N.W. to S.E. beside the course of the Coventry canal and the river Anker. The towns of Atherstone, Nuneaton, and Bedworth, are in their immediate vicinity.

This range, like that of Bromsgrove Lickey, rises through an extensive tract of red sandstone, which is seen advantageously at Baxterley Heath,

throughout the parishes of Arley, Fillongley, Corley, Allesley, and Meriden, and in a large quarry at Attleborough. The sandstone attains its greatest elevation at Corley, which according to Mudge and Colby's Trigonometrical Survey, is 521 feet above the level of the sea. It is nearly horizontal in its stratification. A thin bed of striated gypsum has been found in it on sinking wells at Higham and Witherley. Its usual appearance is that of the red sandstone of Lancashire, Cheshire, and the midland counties. But on the sides of the road at Meriden it is distinguished by its great conchoidal fracture; and to the north of this spot, in the direction of Fillongley and Arley, its lower strata assume the appearance of a calcareous breccia. In both of these particulars it bears a close resemblance to the red sandstone in the vicinity of Exeter and Teignmouth. The cementing matter of the breccia varies continually even in the same stratum, being sometimes red clay, and sometimes carbonate of lime either amorphous and earthy, or crystallized. The substances thus united into a conglomerate rock are still more diversified, varying in size from grains of sand to pebbles several inches long, and consisting principally of encrinal limestone, greenstone, quartz, and hornstone. The pebbles of hornstone are either red or yellow. A large proportion of the limestone pebbles both here and at Barnford Hill, Frankley, and the Lickey, instead of their usual gray colour agreeing with the uniform appearance of the undisturbed strata of limestone, present the fine yellow colour of Sienna marble. They do not appear to contain magnesia, and evidently owe their peculiar colour to the presence of iron, changing to a brick-red when burnt into lime. Perhaps their colour may have arisen from the infiltration of the red oxyd, which is so abundantly diffused through the base of the rock, and which may have been converted into a yellow carbonate of iron after penetrating the limestone *. The strata vary from one to four or five yards in thickness. In the parishes of Fillongley and Arley quarries of this rock have been worked at various places both for building and for making lime.

Regular beds of limestone are worked at Mr. Williams's pits, half a mile north of Bedworth, Mr. Pinkerton's N.E. of Arbury Hale, and Mr. Ludford's at Hockley in the parish of Ansley †. Thus the limestone seems to occur in a line passing from N.W. to S.E. Its dip is in the two former places towards the W. or S.W.; in the last it is in the opposite direction. It appears to rise from under the red sandstone already described, and probably the

* In Geol. Trans. vol. v. p. 493, Mr. Henslow mentions "*ferriferous carbonate of lime*" as occurring in a similar breccia in the Isle of Man.

† Some account of the mining operations at Ansley is given in Bartlet's *Manduessedum Romanorum*, p. 146.

strata of calcareous breccia repose upon it*. Near Bedworth it crops out and dips one foot in three. It is worked by means of a shaft 43 yards deep, passing through beds of a light greenish blue colour, stratified conformably to the limestone underneath, and all abundantly impregnated with calcareous matter, but approaching either to clay-slate or to sandstone according to the proportion which they contain of soft clay or of siliceous particles. Mr. Pinkerton's pits are from 23 to 30 yards deep, the strata dipping 1 foot in 10.

The coal formation of this district borders immediately upon the limestone, which has now been described. It seems to lie in a narrow trough passing southwards to Wyken and Sow near Coventry, and northward by Baxterley and Baddesley Ensor to Polesworth †. The dip of the beds of coal corre-

* The map and section, Pl. XXVI. fig. 1, 2, are intended to give an idea of what I conceive to be the relative position of the various rocks of this district. I am informed that limestone is found at Baddesley, Kingsbury Wood, Whateley, and Cliff, which lie towards the north-west, beyond the limits of the map. In sinking wells about Whateley, large masses of galena rich in silver have been found in a limestone stratum. Dr. Power of Litchfield, to whom I am indebted for this information, had a mass weighing 17lbs.

† Dr. Power has furnished me with the subjoined table of the strata at Polesworth Colliery.

	yds.	ft.	in.
1. Soil and Clay	12	1	6
2. Rocky brown Clunch.	4	0	0
3. Smut	0	0	6
4. Fire Clay	2	2	6
5. Pimply	2	1	0
6. Bind	3	0	0
7. Bind, and Balls of Ironstone	1	1	0
8. Blue Bind	1	1	0
9. Ell Coal, and Batt	1	1	6
10. Fire Clay	1	0	0
11. Blue Bind	4	2	0
12. Rock	8	1	0
13. Upper Sough Coal	0	2	6
14. Clay and Clunch	1	1	0
15. Rock	1	0	0
16. Coal	0	0	3
17. Fire Clay	0	2	0
18. Bind	1	2	9
19. Black Clod	0	0	8
20. Ironstone Bind	3	2	8
21. Half-yard Coal and Clod	0	2	0
22. Fire Clay	0	2	3
23. Rock	1	0	4
24. Ironstone Bind	3	2	8
25. Slate Coal	2	1	3
26. Fire Clay and Pimply	2	1	0
27. Scurry	4	0	3
28. Bind and Slums	2	1	6
29. Smithy Coal	0	2	4
30. Pimply	4	2	0
31. Black Clod and Ironstone	1	0	2
32. Stone Coal	1	0	0
33. Fire Clay	0	1	2
34. Mainstone	1	0	0
35. Blue Bind	3	0	0
36. Ironstone	0	0	10
37. Blue Bind	0	2	6
38. Rystone	0	0	8
39. Blue Bind	3	0	0
40. Thin Coal	0	1	8
41. Soft Fire Clay	3	0	0
42. Strong Bind	7	0	0
43. Main Coal	2	0	0
	99	1	5

sponds generally with that of the associated limestone. The upper measures contain a large quantity of carbonized wood, and of iron pyrites, either in cubes, arborescent, or mammillary. The beds of sandstone connected with them contain remarkably fine impressions of some of the plants characteristic of coal formations, together with large rounded masses of trap, and pebbles of slate, limestone, and oolite.

In a direction parallel to that of the formations now described of red sandstone, limestone, and coal, rises a range of hills of a more ancient character. Their whole length is about eight miles. They commence immediately above the remains of Merevale Abbey near Atherstone, and at this part of their course they are intersected by transverse valleys, which are adorned with wood and pasturage, and at the same time in consequence of their depth distinguish this tract of country by the picturesque characters of alpine scenery. The range diminishes in height as it advances towards the S. E. Beyond Griff Hollow it sinks beneath the level marshy plain, which is watered by the river Anker; and, bursting again through the alluvium at Marston, it terminates about half a mile to the south of the Ashby canal.

The fundamental rock of these hills is grauwacke, instead of which quartz-rock constitutes the middle portion of the range, the whole being traversed by numerous beds and dykes of greenstone. It may obviate misapprehension to mention, that this is the same range, which is represented in Conybeare and Phillips's Geology as consisting of "coal-shale" and "millstone grit." The grauwacke is seen at almost every opening into the hills from Merevale Abbey to Hartshill, and nearer their southern extremity from Chilvers Coton to Marston. Its dip is generally westward, varying from 20° to 70°. It commonly divides by its structure of separation into rhomboids, and exactly resembles the various appearances of the same rock as seen on the confines of Wales and Shropshire, and through the schistose districts of Devonshire and Cornwall. Among its varieties the most interesting on account of its mineral contents is that of Hartshill Heys, which constitutes the "country" of the rich ore of manganese noticed in Geological Transactions, vol. i. p. 168. 2nd series, and which is like the killas at the southern promontory of Mount Edgecumbe in Devonshire, micaceous and unctuous, of a deep red colour, and readily crumbling into a rich red loam. Other specimens glitter with mica throughout their substance, and may be considered as analogous to the rock at the southern extremity of the Malvern Hills, which has been erroneously called mica-slate. A barren eminence between Griff Hollow and the Coventry canal contains slate, which may be compared to that quarried in the neighbourhood of St. Germains in Cornwall.

The quartz-rock occupies the middle part of the range from Hartshill to the spot where the road to Nuneaton crosses the Coventry canal. Its strata, as well as those of the associated grauwacke, generally dip westward at an angle varying from 40° to 70°. Their surfaces present the same waved and swelling appearance, which characterizes the rock at Bromsgrove Lickey and Powis Castle. I have not however discovered here any organic impressions.

Here are found veins of sulphate of barytes, exactly resembling that which occurs in the trap-rocks of the Malvern Hills. In all other respects the quartz-rock of this range agrees with that of Bromsgrove Lickey. Numerous quarries are opened in it; the rock, in consequence of its hardness and its disposition to break into small angular pieces, being used for making roads in all the surrounding country. As it becomes at certain parts more ferruginous and argillaceous, it passes into the ordinary appearance of the grauwacke as already described.

The last substance to be mentioned as entering into the composition of this range is the greenstone, which throughout its course forms either beds in the grauwacke conformable to its stratification, or dykes in the direction of its cleavage. Of these the most remarkable are in Merevale Park. The house formerly called Mere-cliff, and now the residence of D. S. Dugdale, Esq., stands upon the northern extremity of a great dyke, which traverses the park, and, rising in broken wooded eminences above the remains of the softer grauwacke, gives to this demesne its peculiar beauties. In one quarry within the park, veins of calcareous spar and hematite pervade the trap; in another it is seen including fragments of the grauwacke. Beds of greenstone are seen with the grauwacke, in which they lie, in quarries beside Merevale Church, and in the Atherstone Outwoods; in both of these situations the strata dip westwards, at an angle of about 30° in the former instance, and 45° in the latter. Omitting several intermediate localities and passing southwards, we may notice a large mass of greenstone intersected by the Coventry canal, rising upon the southern extremity of the hills of quartz-rock, and where it is contiguous to the quartz-rock, including fragments of it. Another considerable bed is seen at Chilvers Coton, having both above and below a soft unctuous clay of a lively red colour mottled with light green. Still further south, a large mass of greenstone breaks through the grauwacke at Griff Hollow, disturbing its stratification and sending through it some minor branches. The rock, of which these branches consist, is very hard and compact, breaking with difficulty into remarkably sharp fragments, and devoid of any crystalline structure. Its colour is greenish gray, and its fracture splintery. Some beds of it are seen, as represented in Pl. XXVII. fig. 3. in a perpendicular face

of rock under a shed belonging to "the Newdigate Arms." The mass from which these branches appear to proceed, is about 12 yards thick. It is coarse-grained and perfectly crystalline, but exceedingly tough. Veins of crystallized quartz are found in its vertical rents. Besides its base of hornblende and felspar, it contains, in small disseminated portions, iron pyrites, calcareous spar, mica, and a soft olive-green substance, which seems to be serpentine *.

Another bed, in which an extensive quarry has long been worked, is at Marston, where the grauwacke formation terminates. This bed is more than 10 yards thick, and dips east 1 foot in 3. It exhibits veins passing through it in planes nearly vertical, and containing carbonate of lime with siliceous crystals from the smallest size to that of 5 inches in length. These crystals are of the usual form, and envelop portions of the calcareous spar.

6. The last detached groups of the rocks, usually denominated Transition, are those of Leicestershire. As the vicinity of Charnwood Forest has been described, I shall confine myself to a district of much smaller extent, separated by an interval of 8 or 9 miles only from the spot which we have just left. This district lies a few miles east from Hinckley, on the right of the high road from that town to Leicester, and in the parishes of Shilton, Croft, Stony Stanton, and Sapcot. All this region consists of a coarse-grained crystalline greenstone, rising in rocky eminences, between which are situated level plains of alluvium, watered by brooks and sometimes inundated by floods. Such a plain extends from below the village of Stony Stanton to Croft. At this place the stream is discharged between two precipices of greenstone of such elevation, that, if they had not been disjoined, the whole plain above them would have been a lake. The villages of Stony Stanton and Sapcot are on one ridge of rock. But by far the most considerable eminence, and that which presents the most evident characters of a trap formation, is Croft Hill, which runs for nearly half a mile in a direction from N.W. to S. E. The rock is here sometimes porphyritic; and its felspar has a red tinge, which on exposed surfaces is so much increased as to produce, when seen from a little distance, the lively red colour of many syenitic rocks. It has a structure of separation by parallel planes nearly vertical; and by other horizontal planes it is divided into great rhomboidal masses, but without a columnar arrangement. It contains in general no veins of any kind. I only found one exception in a quarry at its eastern extremity, where it is intersected by veins con-

* A similar greenstone is described in Geol. Trans. vol. iv. p. 21, as occurring in the Coley Hill dyke, Northumberland.

sisting of a coarse serpentine, with white talc crystallized in radiated laminæ and with a fine pearly lustre, but changing by decomposition into a soft and very unctuous powder. The occurrence of trap rocks in some situations towards the north-east, as at Barrow Hill near Shilton, and at Potter's Marston and Enderby, indicates the probable extension of this formation to Charnwood Forest.

XVI.—*Remarks on some Parts of the Taunus and other Mountains of the Dutchy of Nassau;—in Explanation of Specimens presented to the Geological Society of London.*

By Sir Alexander CRICHTON, M.D. Knt. G.S.W. F.R.S.

VICE-PRESIDENT OF THE GEOLOGICAL SOCIETY, MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF GÖTTINGEN, HONORARY MEMBER OF THE IMPERIAL ACADEMY OF SCIENCES OF ST. PETERSBURGH, ETC.

[Read Feb. 3rd, 1826.]

THE fossil remains of organized bodies belonging to the grauwacke, together with the rocks and minerals which I have the honour of presenting to the Society, were collected in various excursions which I made last autumn in the south and central parts of the dutchy of Nassau.

The chief object of my journey was to witness the medical effects of the many remarkable mineral waters with which that part of Germany abounds, and which are very different from any that are found in Great Britain. This must plead my apology for a want of more minute details in some of the geological observations which I have had occasion to make.

The dutchy of Nassau is a very mountainous country, except on its south frontier, where it comprehends a part of the valley of the Mayne. Its mountains are a part of the great and well known formation of transition and trap rocks which extends from the north-west of Germany, across the Rhine, in the direction of Valenciennes. But those of the dutchy have received the name of the Taunus; although from the little that Tacitus has said concerning them, it appears that the appellation was given by the ancients to the high mountains in the immediate neighbourhood of Wiesbaden, where a new Roman colony had been founded, and where the empress Agrippina was born *.

The boundaries of the modern Taunus mountains are the Westerwald on the north, and the valley of the Mayne on the south. The valley of the river Wetter, called the Wetterau, is the eastern boundary, and the Rhine the

* Annal. lib. i. cap. 56. et xii. 28.

western one. The extent from south to north along the Rhine is from Assmanshausen, nearly opposite to Mayence, to a little below the mouth of the river Lahn, in the neighbourhood of Coblentz. The group of mountains called the Hundsruche on the west of the Rhine, is in point of fact a continuation of this chain, being of the same geological character and lying in the same direction. The mountains of Nassau are divided by the valley of the Mayne from the mountains of the Spessart and the Odenwald on the south. After being interrupted by the basalt of the Westerwald on the north, they sink under the formations of Westphalia. Any one travelling from Mayence to Francfort sees on his left hand the whole chain of what ought strictly to be called the Taunus Mountains. Their highest point is the Feldberg, esteemed to be about 2600 Parisian feet above the level of the Mayne.

This chain, which is the highest in the dutchy, differs from the minor groups which lie to the north of it, inasmuch as it is composed of talc slate and quartz slate on its south side, and of grauwacke on the north declivity. The talc slate dips downwards, running into the mountains with a north-west direction, while the grauwacke on the opposite side rises upwards from the valley in a south-east one. The south brow of the mountain is made up of the basset ends of the talc slate. Its direction and inclination may be traced, especially close to Wiesbaden, in numerous and extensive quarries. The inclination and direction of the grauwacke, on the opposite side, are exposed to view by natural sections, wherever the ground is bare.

This kind of structure leaves on the summit a space or trough, to be filled up, either with very short strata, or with some unconformable matter. The summit is everywhere composed of a thick bed of quartz-rock.

Although this quartz is very compact and tough in many places, yet with a good glass, scales of talc may be discovered in it. In some parts it is dark-coloured, also red, and ferruginous; in others, white or gray. Two places were pointed out to me, (by Mr. Stifft, general superintendant of the mines of Nassau, to whose kindness and accurate knowledge of the dutchy I owe much of what I saw,) in which the quartz formed isolated rocks about 16 feet high on the summit of the ridge. They lie on the right of the road from Wiesbaden to Ems, in the middle of a forest, and are known by the names of the Spitzerstein and Alterstein.

The mixture of iron oxyd and talc, by permitting the admission of moisture, favours disintegration; and as the brow of the mountain is covered with blocks and fragments of it, there is good reason for supposing that the Spitzerstein and Alterstein are the remains of a higher ridge.

Quartz slate from a quarter of an inch to two inches in thickness frequently alternates with the talc slate on the south declivity. It abounds near Schlangenbad, a wild and sequestered spot, remarkable for the cosmetic virtues attributed to its waters. The talc slate is frequently traversed by large veins of crystalline quartz, in many parts of a pale red and amethystine colour. The schistose quartz is found in a few low mountains, on the left bank of the Lahn, opposite the baths of Ems.

In the south chain bordering the valley of the Mayne, the union of the strata of the opposite sides is nowhere to be seen. All the roads which lead from the valley of the Mayne into the heart of the dutchy, pass over the ridge, and descend on the grauwacke.

At the base of these mountains towards the Mayne, masses of conglomerate are common. They consist of rounded and also angular pieces of quartz, cemented by talc and a little ferruginous clay. This degenerates into a thick bed of sandstone, which spreads itself out to the distance of about two English miles from the foot of the mountains, over the tertiary formations of the valley of the Mayne.

This sandstone is composed of quartz sand, oxyd of iron, and talc; and if a piece of it were exhibited without any account of its position, it might easily be mistaken for the English new red sandstone. It is fine-grained, and of various shades of colour, passing from yellowish white to deep yellow, and from light red to dark brown. Its particles have very little cohesion. Many quarries of this sandstone are to be seen close to Wiesbaden, where it is dug for mortar. It terminates in loose sand on the surface of the calcareous deposits of the valley, and, from its constituent parts, appears to have been produced by the attrition of the talc and quartz slate.

A strong and copious salt-spring is met with at the base of the mountain near Soden. From this source the salt was extracted for many years by the usual processes; but an exclusive privilege of selling foreign salt having been lately sold by the government to some individual, this establishment has fallen into decay.

In the village itself are three copious sources of mineral water, all of which contain muriate of soda, although in smaller quantity than the one just mentioned. They also contain a great proportion of carbonic acid, and some iron. I know of no mineral waters similar to them. That they might be usefully employed both as baths and external medicines, especially in scrofula, rheumatism, and many diseases arising from worms and chronic weakness, is probable from their composition. But although their value begins to be appreciated in the neighbourhood, yet the smallness of the village and the want

of accommodation for a number of visitors, show that they are not yet in vogue*.

The ascent from Soden to Konigstein is steep, and about two English miles in length. The road is formed of the quartz and talc slate. The height is about 1800 feet above the level of the river; the view extensive, rich, and beautiful; and the summit is diversified by small hills. At a short distance from the village of Konigstein, which is on the top of the mountain, one of these (the Falkenstein) exhibits large plates of the *talc-schiefer*, of which it is composed, standing up in all directions; some are perpendicular, and the rest at various angles. Other hillocks in the neighbourhood consist of shattered plates of the same schistus, in less disorder.

The grauwacke, which occupies a great portion of the dutchy of Nassau, passes from the coarse-grained and quartzy kind to that which is composed of finer and more micaceous parts, and also to one which is more argillaceous. The grauwacke slate, which intervenes between the strata of the coarser kind, is very argillaceous, and also full of mica. Its prevailing colour is bluish green. It is foliated, easily broken, and gives a strong smell of clay when breathed on.

These varieties, which compose the bulk of the mountains on the river Lahn, do not alternate regularly with each other. Several beds of hard grauwacke are seen lying on each other without the intervention of the slate. In other places the grauwacke slate intervenes, or a half-pulverulent argillaceous matter lies between the harder beds.

The strata of the grauwacke are in general several feet thick. The slate is seldom more than one foot and a half in thickness, and frequently only a few inches. It is sometimes as thin as paper. In some places it is employed for roofing houses.

These mountains are rich in petrifactions. In the quartzy beds are found the remains of encrinites, and in the argillaceous and micaceous beds numerous casts of shells. Many of these I collected on the top of a high mountain called the Kemmenau, about a league from the baths of Ems, and others from one which rises close to the baths themselves, at a place called the Moshutte, about half way up the mountain †.

* The muriate of soda, as a mineral substance, is generally associated with the new red sandstone: but at Soden, the mineral waters containing it rise at the base of the transition rocks near to that place where the tertiary formations of the valley abut against the mountain. I know not if they have ever attracted any attention from geologists.

† There is a great resemblance between the casts of some of the shells at the place above specified, and those from Snowden. I have directed figures of the most distinct specimens to be prepared; and, if they prove interesting, shall probably take a future opportunity of laying a description of them before the Society.

Many of the grauwacke mountains appear to have been rent from top to bottom, exhibiting complete sections of the strata. Along the beautiful and ever-varying valley of the Lahn, from its mouth near Coblentz to the city of Dietz, fine sections occur. Partial contortions and faults are frequent in these strata, which, in general, lie at a high angle.

These mountains are rich in metals, especially in argentiferous lead ores. Near the village of Ems are two productive mines of this description. Half way between Ems and Holzapfel is another; and at that town is a fourth, rich in argentiferous galena, which belongs to the princess of Schomburg. Many veins of carbonate of iron and ferriferous carbonate of lime, besides cobalt and copper, are associated with the lead ores.

In following the Lahn towards its source, we do not meet with any other variety of rock on its borders than grauwacke, until we reach Baldouinstein. Here transition limestone first appears. The ruins of Count Baldwin's Castle stand on an insulated rock of this substance. A mountain stream has laid bare the basset edges of the grauwacke slate at this place; and on ascending the road to Schomburg, the limestone again appears on the right of the road. A little higher up is a dark-coloured porphyry. Still higher on the road to Dietz, there is a thick but not extensive bed, of a pulverulent substance, which is generally yellowish white, but in some places violet-coloured, or of a reddish hue. The highly coloured parts are chiefly in the ravines. This bed lies on the surface, extending about half a mile on the road to Dietz. It contains numerous rounded pebbles of pure quartz, of various sizes, from that of a large garden-pea to that of a full-grown Swedish turnip. From some experiments I have made, it seems to be almost pure silex coloured by iron. It is highly phosphorescent.

If, instead of following the road to Dietz the traveller ascends the mountain of Schomburg, and then, keeping to the right, crosses over to its opposite brow, he meets with a quarry of stone of a very peculiar character, to which the old miners of the dutchy have given the name of Schalstein, which, literally translated, means plated stone. The chief ingredients of this rock are chlorite, carbonate of lime, and silex, the proportions of which are by no means constant. Its prevailing colour is a pale apple-green. It is compact and hard in some quarries, and very foliated and fragile in others. When combined with much silex it strikes fire with the hammer, and requires repeated blows to be broken. Where the carbonate of lime and chlorite prevail, it is imperfectly slaty; and after it has been long exposed to atmospherical influence it may be broken by the fingers. In all cases it effervesces with acids, but in its very compact state it must be previously pulverized in order

to produce this appearance; whereas, in its softer parts, the same may be observed by letting fall a drop of acid on it. This rock, both in its slaty form and also where it breaks into thicker and longer masses, abounds in veins of compact carbonate of lime. It is used for architectural purposes.

In the mountain of Schomburg this stone breaks into large thick blocks, two of the sides of which are flat and nearly parallel: the others are splintery. The slaty variety I met with in the valley of the river Aar, which falls into the Lahn near Dietz. In this slaty kind it is common to find the carbonate of lime in patches, giving an amygdaloidal character to the stone. The true native situation of this rock is the dutchy of Dillenbourg. Here it is always accompanied, as I am informed, with transition limestone, and contains great beds of a very rich iron ore lying between the schalstein and limestone.

At Dietz the transition limestone borders both sides of the river; and immediately reposing on this, at Oranienstein, is a thick hard bed of compact crystalline dolomite. This is the newest formation which I saw in this neighbourhood, excepting always alluvial deposits.

The transition mountains which I have been describing are pierced in numerous places by basalt. In the short distance between Ems and Holzapfel are no less than four instances of the kind:—and one of these is accompanied by circumstances deserving notice. Immediately behind the house of the inspector of the mineral waters of Fachengen, a grauwacke mountain rises, on the top of which is a basaltic quarry, of an imperfectly columnar structure. Next to the basalt on one side is greenstone; on the other side, mountain limestone. The grauwacke lies at a high angle, and incloses the greenstone and basalt, and the limestone has the appearance of dislocation.

Of the Valley of the Mayne.

The valley lying between the Taunus Mountains and the river Mayne consists of shelly limestone and marle, which are easily examined in several quarries on the declivities of the low hills which border the river. The specimens which I collected, were taken from a quarry near Oberrad; from a quarry at Mulbach, near to Wiesbaden; and the rest from Hogheim, facing Mayence.

At Oberrad the beds are of various thickness, separated by beds of marle; this limestone in its lower beds is compact, fine-grained, and of a splintery fracture. The uppermost bed is about three feet thick, and lies about two feet under the surface. The next is about six feet thick: a much thicker one follows. This limestone and the marle are full of shells, which according

to Mr. Sowerby, who has examined them, are chiefly paludinæ resembling the P. thermalis.

At Hogheim the upper and lower beds, which are easily distinguished by their different degrees of hardness, are often found nearly on the same level. These also contain the same species of paludina as that found at Oberrad; and also some cyrenæ resembling the C. obovata, a helix, a modiola, a mytilus, and a cerithium or potamis.

At Muhlbach the shells are chiefly paludinæ.

The fossil bones, of which there are nearly forty specimens, were found in the quarry at Muhlbach, about 60 feet deep under a limestone bed in marle. They are all fragments, and were so fragile as to break on being touched. Unfortunately they are too indistinct to justify an opinion concerning the animal to which they belonged; but from the portions of two teeth which are tolerably well preserved, Mr. Clift, who has been so kind as to examine them, thinks that one belonged to an animal nearly allied to the Lophiodon Tapiroides, and that the other is one of the molares of an animal resembling the recent Sumatran Tapir.

This calcareous deposit is bounded on the north by the Taunus, on the south by the Odenwald, on the south-east by the Spessart, and on the west by the alluvial deposits of the Rhine. Many facts led me during the examination of the valley, to suppose that the whole of this calcareous deposit lies on basalt. These facts I shall state in a few words.

1st. A little way to the south-east of the Warthberg hill near Sachsenhausen, and consequently at a very little distance from the Mayne, a quarry of basalt rises through the calcareous deposit.

2dly. Basalt is quarried at the eastern foot of the same hill, and also on the opposite side of the river under the calcareous beds.

3dly. At Steinheim, about one mile and a half from Hannau, on the south side of the Mayne, the basalt rises again; and several quarries of this substance are to be met with in the neighbourhood.

4thly. A little to the south of Steinheim several quarries of basalt have been opened under the calcareous deposits. In some of these the columns are about 30 feet high.

5thly. On the road from Steinheim to Offenbach is a fine quarry of columnar basalt.

Following the high road south towards Darmstadt, we gradually lose the calcareous marle, and begin to find fragments of primitive rocks, such as granite, gneiss, syenite, &c. At Rosdorf, south-east of Darmstadt, is the last appearance of basalt in that direction.

XVII. *Notes on the Geological Structure of Cader Idris.*

By Arthur AIKIN, Esq. F.G.S., &c.

[Read June 16th, 1826.]

CADER IDRIS is a mountain ridge running almost E. and W. to the south of, and nearly parallel with, the course of the river that flows from the town of Dolgelle to the sea at Barmouth. Its length is about eight miles and a half in a straight line. It consists of a winding summit ridge somewhat depressed at each end, but on the whole considerably higher than the neighbouring mountains. Its western extremity terminates on the sea-shore in a steep slope ending in a cliff, the entire height of which is about 1500 feet: its eastern extremity called Geygraig, is 2267 feet high, the summit is 2914 feet, and the other points are of intermediate altitudes between those just mentioned, and were ascertained trigonometrically by Lieut.-Col. Colby and his assistants.

The northern face of the mountain is so steep as to be in few places accessible, and, in many, approaches to perpendicular. The southern face is a long slope with a varied undulating surface, consisting chiefly of bog and sheep-walk, and concealing from view the subjacent rock. The summit overlooks two remarkable hollows. One, of a semi-circular figure, commonly called the crater, forms part of the northern face: the two extremities of the semicircle are respectively 2894 and 2655 feet high. The descent to the Goat's Pool (Llyn y Gafer), which lies in the bottom of the crater, is above 1000 feet, and almost perpendicular: the pool itself is 1835 feet above the level of the sea.

The other hollow, called Cwm y Cae, is on the S. E. of the summit: it is of an irregular elliptical figure, with a break or opening on the S. E. into the valley of Tal y Llyn: at the bottom of this hollow is also a pool about 1660 feet above the level of the sea.

The hill called Mynydd pen y Coed is the highest of those which stand out on the southern slope of the mountain, being 2504 feet. The upper part is but little obstructed by vegetation; and wherever the rock can be seen it evidently consists of beds of slate, very regular, and rising N. E. by N. at an angle of about 35°: on the N. E. end, however, of the hill, near the edge of

Cwm y Cae, the beds, without changing their direction, bend up sharply so as to increase their angle to about 50°. Induced by this circumstance, I took a line of section from this part of the hill by the edge of Cwm y Cae, over Craig y Cae, to the margin of the crater, and thence to the Goat's Pool. Mynydd pen y Coed consists almost entirely of strata of soft bluish-grey clay-slate. The beds which lie in succession below this, and occupy the ground to the edge of the crater, are grauwacke, consisting of coarse blackish-blue slate inclosing concretions of splintery quartz more or less earthy, and compact splintery quartz with imbedded crystals of pyrites, in parts more or less ochrey and cellular, probably from decomposition of the pyrites.

To these succeed beds of quartz-rock differing from the preceding only in being more vitreous, and these last rest upon a bluish-grey quartz-rock rendered porphyritic by a few crystals of felspar.

These beds all rise N.E. by N., but their angle of elevation is continually increasing, and the last bed forms the summit of Craig y Cae. The space from this to the margin of the crater is occupied by alternations, in nearly vertical beds, of soft glossy clay-slate, of coarser slate with ochrey spots and small cells, and of grauwacke with concretions of quartz, in some beds rendered porphyritic by imbedded crystals of felspar as well as quartz. Porphyritic quartz-rock also occurs, as well as slaty potstone, that is, slate intimately mixed with steatite. There is also inserted about the middle of this series a single bed of a brownish-grey rock, which effervesces strongly for a short time with acids, and by exposure to weather becomes porous and of a darker brown. It appears to be ferruginous quartz, intimately mixed with carbonate of lime.

The next bed (which forms part of the summit of Cader Idris) is composed of globular concretions a foot or more in diameter, which separate into compact angular pieces. This rock is excessively hard and strongly resists decomposition ; in consequence of which it appears as a ridge or wall, a few feet higher than the adjacent beds. It contains numerous specks of pyrites, and has small roundish prominences on the weathered surface, somewhat resembling the orifices of tubes. In very thin shivers it melts into a black glass, and is probably a trap-rock.

The perpendicular wall of the crater is between 900 and 1000 feet in height, and presents the following series of beds from the top.

Three or four alternations of slate and grauwacke.

Fine-grained greenstone in irregular columns.

Slate.

Fine-grained columnar greenstone similar to the preceding.

Slate inclosing a bed of calcareous iron-shot quartz.

A porphyritic rock, consisting of quartzy compact felspar containing, imbedded, crystals of felspar, and a green matter which decomposes by exposure to weather, leaving cells lined with red oxyd of iron. This bed rises about N.W by N., and is composed of irregular columns from 6 to 14 feet long. It ascends obliquely on the west, to that part of the ridge of the mountain called the Saddle, 2655 feet high, which is overspread with columns similar to those just mentioned, except that they are mostly lying prostrate: it also forms the basin in which the Goat's Pool at the bottom of the crater is contained.

On the northern side of the pool is a kind of mound consisting of a rock composed of chlorite, calcareous spar, quartz and glassy felspar. The calcareous spar is white, or of a dull purplish colour. There are several of these beds; of which the upper is a kind of conglomerate imbedding roundish masses of the same kind of rock, but harder, and with a smaller proportion of calcareous spar, and large angular pieces of slate. Below this is a bed harder and more compact than the former, and arranged in irregular columns like starch. This rests upon a more slaty rock of the same kind.

All these beds decompose by exposure to weather through the decay of the calcareous spar, showing the greater part of the mass to consist of this ingredient: some of the decomposed pieces are very light and spongy, and I presume are the substance which by some persons has been described as cellular lava. The relation of these beds to the columnar porphyry which precedes them I have not been able satisfactorily to make out in this place; but upon the whole I am inclined to think that they rest upon the porphyry, as this latter rock makes its appearance on the north as well as on the south of them.

These calcareous beds being readily distinguishable from the others among which they occur, I endeavoured to trace their extent. To the east, as far as the ridge of the mountain stretches, the valley in which they ought to be found is so covered with peat bog and with large masses that have fallen from the cliffs above, that I could not examine it with the requisite minuteness: I obtained, however, a very good section of the descent northwards from Geygraig (the eastern extremity of the mountain), without finding these beds; and I conclude that they do not exist there. I then examined the foot of the ridge to the west of the crater, and had the satisfaction of finding what I sought below Twrr mawr, one of the points of the mountain 2148 feet high. An inaccessible precipice of irregular columnar shafts occupies the first 700 or 800 feet from the top, which, lower down, breaking into groups or steps, allows of examination. Here I found a columnar porphyry, evidently the same rock as is associated with the calcareous beds at the Goat's Pool. Three of these façades or steps consist of nearly vertical coarsely slaty tables, which are again

divided by vertical joints at right angles to the tabular structure, and thus form tolerably regular quadrangular columns. Between every two steps of porphyry lies a bed or step of green calcareous rock disposed in rude irregular columns; and, still lower down, is the same calcareous rock in coarsely slaty beds, resting on hummocks of soft and not very crystalline greenstone, and interstratified with common and indurated slate. The beds rise N.W. at an angle of about 85°.

The point or projection of the mountain next to the west of Twrr mawr is called Mynydd Coeswyn, and presents appearances very similar to those described. The top is slate, resting on a very hard compact porphyritic greenstone in thick curved tabular masses, which are rudely subdivided into rhomboidal columns, the convex side of the curve being outwards. At the foot of the porphyry are beds of common blue slate rising W. by N.; then comes the green calcareous rock, imbedding angular pieces of slate; then nearly vertical beds of a heavy black slate; then imperfectly slaty grey schist; then beds of the green calcareous rock in which the general slaty structure may be seen at a little distance, but also passing into the large lenticular and obscurely columnar structure. These latter beds rest immediately on columnar greenstone; which at the plane of junction, but no where else, incloses or has involved masses of the calcareous rock, so cellular as to appear like large sponges.

A very remarkable mountain (the name of which I could not discover, and which I therefore for distinction's sake call the Stony Mountain) extends for about two miles parallel to Cader Idris, forming the northern boundary of the little valley in which the Goat's Pool and another small lake are situated. The height of it is about 1700 feet, and it is distinguished from most others in its neighbourhood by several characters. On looking towards Cader Idris from Dolgelle, the white roundish crags of this mountain are very conspicuous; and their height is such, that only one peak of Cader Idris appears beyond and above them. On a nearer examination it is found to be composed of rounded tubercular crags and hemispherical bosses of trap, like enormous ovens, rising group above group, the intervals between which are filled up with coarse pasture and bog. The surface of the bosses is comparatively smooth, and generally reticulated by veins of quartz usually not more than half an inch thick; some of them, however, are considerably wider; and areas occur occasionally, four or five yards across, of white massive quartz several inches thick, with an obscurely slaty structure adhering to the surface of the trap. Many of the groups, when seen in profile, appear to be of a very irregular and thick slaty structure; but, when viewed in front or looking down upon them, are

evidently clusters of columns laterally aggregated and intersected by oblique irregular joints. The columnar structure is remarkably perfect on the northern side of the mountain, where terraces of columns sloping towards the body of the mountain, (each terrace in succession retired behind the lower one,) present a flight of enormous steps, and show this remarkable character of the trap-rocks in great perfection. The base of each group generally consists of slaty greenstone and porphyritic slate surrounding the group, and rising up to it on all sides, and therefore evidently a member of this trap formation. On the slaty greenstone rests a bed of highly indurated siliceous schist, which like the other regular strata rises N. by E. or W.

On the south side of the mountain may be seen the connection of the green calcareous rock with those just mentioned: its lowest bed rests on a porphyritic grauwacke, and this latter on a slaty greenstone.

About half way between Dolgelle, and the Stony Mountain, on the Towyn road, is a large quarry of syenite. It is composed of green hornblende intimately mixed with compact felspar, and is rendered porphyritic by concretions of lamellar flesh-red felspar. It is traversed by numerous veins of quartz, in which are imbedded fibres and curved crystals of pale wine-yellow thallite. On the S.W. flank of this syenite are applied nearly vertical beds of schist running about N.W. and S.E. Those beds that immediately rest on the syenite are considerably indurated, the others are less so. Beds of potstone are found very near the schist, and probably interstratified with it. The northern side of the syenite is covered by a soft dark green steatitical rock obscurely slaty, on which rest beds of a green slaty rock not very different from the former, and these are covered by beds of soft blue slate: all these beds rise at a high angle S.E., that is, towards the nucleus of syenite; and the green steatitical beds are penetrated by veins of quartz and thallite, stained green by carbonate of copper.

The descent northwards from Geygraig, the eastern extremity of Cader Idris, also shows in a very interesting manner the connection of the trap with the stratified beds. The south-western part of the flat surface of Geygraig is covered by peat, so as to conceal the subjacent rock; but the north-eastern end consists of a few beds of unaltered blue slate, to which succeed beds of schist disturbed in position, in some places indurated, in others cellular; and in every part containing imbedded lumps of very hard porphyritic greenstone: sometimes the schist contains numerous small glands of quartz and of felspar, and is largely mixed with siliceous schistus of a dull green colour. This rests on highly inclined beds of a porphyritic slate, and this latter on imperfect amygdaloid, which itself rests on the columnar basaltiform trap.

On descending from Geygraig to Dolgelle by the edge of the valley of the Aren, first occur craggy hummocks of massive trap more or less columnar, surrounded by slaty trap in mantle-shaped strata, and covered in different parts by beds of a shining micaceous clay-slate. Near Dolgelle the river flows over beds alternately slaty and massive; the former are distinctly steatitical, and will probably be considered as potstone; the latter differ from them in being harder and consisting of a larger proportion of quartz. Sometimes they contain carbonate of lime, and then effervesce briskly for a short time with acids.

On tracing up the Dolgelle river, the Ynnion, for a few miles towards Bala, no rock occurs *in situ* except massive crystalline greenstone; but on turning to the N. up a small lateral valley, I found beds of the same kind of rock as appear at Dolgelle in the bed of the Aren, some of which are sufficiently calcareous to burn into a reddish-brown sandy lime, and which therefore may perhaps be called limestone: it contains no organic remains. Beds very similar to these, and in all probability a continuation of them, appear at the foot of the hill at Llaneltid bridge over the Mawddach, on the road from Dolgelle to Barmouth, where they rise N.W. at an angle of about 20°, and form the upper members of a series of the grauwacke formation, composed of common blue slate, of finely foliated grey slate more or less calcareous, and of coarse green slate. These slaty beds alternate with sandstone consisting chiefly of quartz, in grains varying from a very minute size to that of hazle-nuts, intermixed with calcareous spar, the whole cemented together partly by quartz and partly by carbonate of lime. This sandstone, in the lower beds, is less calcareous, and mixed more or less with scales of slate; it also by exposure to weather splits into masses somewhat like starch, which stand nearly at right angles to their planes of stratification.

From the facts above detailed, it will I think be evident, that Cader Idris and the ground between that mountain and the Mawddach, as well as the northern boundary of the valley, consist of various well-known transition rocks rising in general N. by E. or W.: that the beds both at the northern and southern extremities are at low angles not greater than 20°; that the intermediate beds are at high angles approaching to vertical; that they rest upon and are interrupted by trap-rocks more or less columnar; that the trap-rocks themselves are surrounded in many places by mantle-form strata, which in some instances are obviously of the same materials as the trap, and differ only in structure,—but which sometimes bear a less obvious resemblance to the trap; and, from exhibiting transitions from that rock to those which compose the regular strata, are probably the latter, more or less changed by contiguity with the trap.

XVIII.—*On the Strata of the Plastic Clay Formation exhibited in the Cliffs between Christchurch Head, Hampshire, and Studland Bay, Dorsetshire.*

By Charles LYELL, Esq. F.R.S. F.L.S. F.G.S.

[Read March 17th, 1826.]

THE range of coast between Christchurch (or Hengistbury Head), near Muddiford in Hampshire, and the southern side of Studland Bay in Dorsetshire, is nearly 17 miles in length. It presents fewer geological phænomena of interest than its extent might have led us to expect; but a detailed examination of these Cliffs serves to complete the history of our Southern Coast, of which so large a portion is now illustrated by memoirs published in the Transactions of the Geological Society.

The strata about to be described belong exclusively to the plastic clay formation; and it is necessary to premise that the uppermost bed of this formation is seen to the East of Muddiford. In an account of the strata between Hordwell Cliff and Muddiford, published in the last volume of the Society's Transactions, Mr. Webster has referred the sand that rises from beneath the London Clay at the western extremity of Highcliff, about a mile to the East of Muddiford, to the plastic clay-formation. In this sand he observed fragments of lignite, and branches and leaves of plants. Not far from the spot where it rises, it is cut off by denudation, the valley of the Stour and Avon here reaching the coast; and the interval between this and Muddiford is covered up with gravel and blown sand. A great quantity of fossil wood retaining the woody fibre in a remarkably perfect state is thrown up by the sea on the beach at Muddiford, and indicates an abundance of these remains in the strata there, acted upon by the powerful current that sets in round Christchurch Head. The force of this current carries away the materials brought down into the estuary of the Stour and Avon, and entirely prevents at Muddiford that gain of land so common at the mouths of rivers. In the bottom of the valley higher up, between Muddiford and Christchurch, the river has deposited

a bed of alluvial mud. The junction of the rivers Stour and Avon takes place about half a mile below Christchurch, which is situated two miles inland from Muddiford. There is a shifting bar of sand at the mouth of the harbour at Muddiford, rendering the river so shallow that it can be forded at low water during summer. Vessels drawing more than five feet water cannot enter. Although there is no accumulation of alluvial gained land at the mouth of the Stour and Avon, Muddiford stands on sand evidently thrown up by the sea, and a trifling accession of soil is derived from this source. The ancient low cliff is now clearly seen a few hundred yards inland, on the north of the village, and the ancient sea-beach at its base forms the present road.

For the space of more than a mile from the mouth of the Stour and Avon to the east point of Christchurch Head, are hills of blown sand, through which the storm of November 1824 broke with great violence. The subjacent strata are entirely concealed along this shore, and there are no means of filling up this chasm in the section: but before arriving at the east point of Christchurch Head a line of ferruginous sandstone concretions is seen on the beach, running out to sea in a direction E. S. E. (See Pl. XXX. No. 1. a.) At Christchurch Head the regular section of the strata is first resumed after the interruption caused by the valley of the Stour and Avon. The strata then are as follows, beginning with the uppermost:—1st. Flint gravel, varying between the east and west points of the Head, from 5 to 20 feet. 2dly. A very fine whitish sand, varying in thickness from 8 to 20 feet. This sand, crops out a little to the W. of West Point. (Pl. XXX. No. 1. b.) 3dly. Sand and loam varying in colour, generally greenish or grayish blue, in parts yellowish, or brown, and often darkened by bituminous matter. (Pl. XXX. No. 1. c.) In these beds of sand and loam are concretions of ferruginous sand, not unlike those of the lower greensand or Shanklin beds, and others of clay-ironstone, resembling considerably in appearance the clay-ironstone of the coal-formation: black flint pebbles occur in some parts of the sand and loam, and sometimes in the concretions. Parallel layers of these concretions, separated by beds of sand many feet in thickness, first appear at the East Point, and increase from 2 to 5 in number as the strata rise towards the West Point. They are very conspicuous, as the concretions are large, and stand out from the cliffs in relief, the soft sand being removed from around them.

A quantity of bituminized wood, and sometimes large flattened trunks of trees occur in the concretions. One of these trees which I measured, was four feet long and two and a half in circumference. The bark or external coat of this fossil plant consisted of a black shining coal about a quarter of an inch thick, the interior being filled with clay-ironstone. There is a large per-

centage of iron in some of these concretionary masses; and as exportation from hence by water must always have been easy, it is probable that the ore used in the ancient iron-works of the Mine Way, at the eastern extremity of Hordwell Cliff, near Muddiford, was procured from this part of the cliff. On the summit of this promontory of Christchurch Head, are pits, from whence ironstone has been extracted in former times, but perhaps for the purpose of building; for some of the late repairs of the church at Christchurch have shown that these concretions were used in filling up the foundations. This series of strata of sand, loam and ferruginous concretions, is more than 20 feet in thickness where it first rises at the East Point of Christchurch Head; and, before its outcrop about three quarters of a mile beyond the West Point, it attains, in parts, the thickness of 50 feet. The apparent dip of the strata in the cliffs is to the East; but the real dip may differ from this, as tranverse sections cannot be obtained. The cliffs of this promontory and to the west of it at the outcrop of the above strata, vary in height from about 40 to above 70 feet. The next bed that rises is a black bituminous clay with lignite (Pl. XXX. No. 1. d.), which is about 12 feet in thickness, and rests on a layer of round black flints. The lignite with which the beach at the West Point is strewed, is probably washed from this bed. Below this, a bed of reddish brown chocolate-coloured sand rises (Pl. XXX. No. 1. e.), inclosing occasional flint pebbles, about four feet thick and resting on a layer of small flint pebbles. Below this is a bed of coal-black bituminous matter, varying from three to four feet in thickness. (Pl. XXX. No. 1. f.) Then a stratum of reddish brown sand rises five feet thick. (Pl. XXX. No. 1. g.) The variety and contrast of the colours of the above strata remind the geologist of the section of Alum Bay. These beds cannot easily be traced far, as they vary in colour rapidly and pass into each other. The bituminous beds in particular, from containing less vegetable matter in parts, change suddenly their appearance. The cliffs become low after the outcrop of these strata, as will be seen by the section, till near a place called Double Ditches *, about three miles from Muddiford, the cliff is only 17 feet in height. Here 12 feet of diluvium is seen at the top, and below it five feet of white sand. (Pl. XXX. No. 1. g.)

At Double Ditches the cliff is about 15 feet high, entirely composed of diluvium covered with blown sand. The cliff continues very low for a mile

* Double Ditches is perhaps a corruption of Double Dikes; for there is an entrenchment here stretching across the low neck of land that connects Christchurch or Hengistbury Head with the main land. This Head has been a defensive position in ancient times, and the old name Hengistbury seems to denote a Saxon origin. There is only one trench, now filled with blown sand, and an agger on each side, which were no doubt provincially termed "dikes."

beyond Double Ditches, consisting of diluvium from 8 to 10 feet thick, covered with blown sand from 3 to 5 feet deep. Agriculture in the neighbourhood of the coast between this spot and Boscomb suffers much by this covering of blown sand. At the foot of the low cliff above mentioned the regular strata are seen at a few points; first white sand with ferruginous yellow streaks, then, at a place called White Pits, reddish brown clay (Pl. XXX. No. 1. h.), then, sand with much vegetable matter. Beyond this to the westward is white sand at intervals, with layers of white decomposed flints extremely light. About a mile beyond White Pits, a bed of sand containing much bituminous matter is seen at the foot of the low cliffs, after which the cliffs rise again to 40, and soon after to 60 feet in height. The cliffs, when they first rise, consist of white and yellow sand 18 feet thick, and white sand below with a brown thinly laminated clay 10 feet thick (Pl. XXX. No. 1. i.); the whole capped with 12 feet of gravel.

From this point to the Flag-house near the mouth of Pool Harbour, a distance of about 8 miles, the section presented by the cliffs is continued so precisely in the line of bearing of the strata, that no new beds rise up; and it is unnecessary to describe it in detail. It will be seen by the accompanying section that the cliffs are intersected by numerous valleys and chines, the principal of which are Boscomb Chine and Bourn Mouth. The prevailing character of the strata throughout this extent of coast is fine white sand; but yellowish and pinkish beds of sand occur, and thinly laminated clays in great abundance, resembling in appearance many of the light coloured argillaceous marls of Montmartre near Paris: but in none could I discover any organic remains, except vegetable impressions, and these very indistinct. The lower sands of this series are frequently ash-coloured, apparently from the admixture of vegetable matters, with which they are charged very irregularly, and they consequently often change colour suddenly. Black bituminous clays are sometimes associated with the ash-coloured sand; as for instance to the east of Boscomb Chine, where, in the lower part of the cliff, ash-coloured sand 15 feet thick appears, with 25 feet of black clay below it. Similar dark beds occur to the east of Bourn Mouth. The following is the section of the cliffs at "The Chines" near Boscomb Chine.

Gravel	25 feet
White yellow and pink sands	60
Ash-coloured sand with vegetable matter . . .	25

Pipe-clay is seen in a few spots, as at the foot of the cliff to the east of Boscomb, and west of Big Durly Chine. I was informed also that pipe-clay

was worked in the interior near Bourn Mouth. Alum sometimes effloresces from some of the clays associated with the white sand where they contain pyrites.

This series of sands, clays, and argillaceous marls, is nowhere exposed to view, so that the entire thickness of the whole cannot be accurately estimated; but it is not less than 150 feet. The cliffs vary occasionally in height, but except where interrupted by chines and valleys, they are rarely less than 60, and appear never to exceed 130 feet. The inclination of the beds is slight, but in the sections in some of the Chines a slight dip to the north is seen. Gentle curves and undulations in the strata are not uncommon, as about a mile east of Boscomb, and between Boscomb Chine and Bourn Mouth. The strata of sand are not always conformable; and this unconformability has arisen from irregularities attending their original deposition, and not from any subsequent disturbances or slips. The diluvium covering this line of cliffs varies from 10 to above 40 feet in thickness, and is chiefly composed of flint-gravel. Sand, however, is in some parts intermixed, and often interstratified with considerable regularity.

After passing Bateman's Chine and the cliff on which the Flag-house stands, the section is interrupted by the mouth of Pool Harbour, and the bar of sand on each side of it, for a space of about two miles and a half. The section is resumed near Studland; but the strata are not continuously exposed, and the junction of the plastic clay-formation and the chalk is very imperfectly exhibited. First, at a spot a few hundred yards to the north of Studland, in a sloping inland cliff protected from the sea by a low sand-bank, yellow and purple sands are seen, and in a few spots, pipe-clay. Nearly opposite the village of Studland, where the section first becomes distinct, the following strata occur, beginning with the uppermost.

1. Vegetable soil . . . . . 2 feet
2. Yellow and purplish sand (Pl. XXX. No. 1. j.) 10
3. White sand, alternating with thinly laminated white clay, containing a quantity of vegetable remains (Pl. XXX. No. 1. k.) 20
4. Sand, occasionally passing into sandstone.

This last bed strikingly resembles some of the ferruginous sand of the Shanklin beds containing similar ferruginous concretions in balls, or, as in the Isle of Wight and Sussex, in long tubes 6 feet (See Pl. XXX. No. 1. l.). Proceeding towards the chalk, we find the cliff occupied by sands mottled with white, yellow, and purple (Pl. XXX. No. 1. m.). These cliffs are sometimes very beautifully marked with concentric stains, exactly imitating the transverse and oblique sections of trunks of trees; and the sand often passes into sandstone.

These beds are about 25 feet in thickness. All these strata opposite Studland are irregular and curved; and if the cliffs were more continuous, more vertical and elevated, they would probably be seen to be contorted like the strata of the same formation in White Cliff Bay, in the Isle of Wight. The section between this and the chalk is very imperfect, the slanting cliffs being covered with vegetation, pipe-clay (Pl. XXX. No. 1. o.) and white sand (Pl. XXX. No. 1. n.) are seen at intervals. The junction of the chalk and sands is buried under a mass of debris; but fragments of a breccia of flint, imbedded in a ferruginous cement, are observed immediately above the chalk. Mr. Mantell has pointed out a similar breccia to me in the beds of plastic clay resting on the chalk near Seaforth in Sussex, where the imbedded flint pebbles have a green coating. I have observed these green pebbles *in situ* immediately over the chalk in the North of Hampshire, and the green pebbles strewed over the chalk near Croydon are probably derived from a bed similarly situated.

Beneath the ferruginous breccia, the chalk for two feet is a soft marl, and minutely striated with yellow and white lines, occasioned perhaps by stains derived from the breccia. The upper chalk with flints then appears dipping gently to the north. The Old Harry Rocks, which are detached masses of chalk, standing out in the sea like the Needles in the Isle of Wight, are not above half a mile distant from this point. I found no animal remains in any stratum between Christchurch Head and Studland Bay; and although a more careful investigation may detect some, they must certainly be rare. The argillaceous strata of Alum Bay, which contain shells, are probably concealed here at some of the interruptions of the section. But the absence of animal and the abundance of vegetable remains are characteristic, both here and on the continent, of the plastic clay or lignite-formation. They are no less characteristic of the ancient coal-formation; and it is also singular, with respect to these two formations of dates so widely different, that the proofs of their origin, whether freshwater or marine, have been considered equivocal. In the ancient coal-formation, as is well known, remains decidedly marine have been found, but never abundantly nor in *all* coal-fields, while shells of apparently freshwater genera have been often found. In France the plastic clay-formation is usually destitute of organic remains; but as lymnææ and planorbes have been discovered in some localities, it is there generally considered as a freshwater formation. The shells of the plastic clay of this country are decidedly marine. Yet none who have compared the beds of plastic clay and lignite resting on the chalk, in France, can doubt their analogy to our own. Neither do such variances oppose any irreconcileable difficulties to the connection of these formations; nor are the variations in the fresh-

water or saltwater character of the shells inconsistent with the supposition that the various beds belong to a contemporaneous formation, which their relative position, their organic remains and mineralogical characters, indicate. If this series of strata was originally deposited in friths, estuaries, or in shallow seas, the phænomena are such as might be expected.

Diluvium.

The diluvium which covers the cliffs between Christchurch Head and the mouth of Pool Harbour, consists chiefly, as I have observed, of flint-gravel; but in some parts layers of sand are interstratified with considerable regularity. The flints have been derived from the chalk; they are broken and partly rounded, but a great portion retain much of their original form and of the white coating peculiar to chalk flints. They do not appear to have been ever subject to the continued action of the waves; and there is a striking difference between the appearance of the flints in the diluvium, and the shingle composed of round pebbles on the beach below, though the latter is formed of the same materials. This remarkable bed of flint-gravel, sometimes 50 feet or more in thickness, is strewed uniformly over the several formations which occupy the cliffs between the eastern extremity of Hordwell Cliff and the mouth of Pool Harbour. There is no observable difference between the characters of this diluvium, whether it covers the lower freshwater formation, the London clay, or plastic clay. The only spot in which an exception occurs, is at the western end of High Cliff, where the sand of the plastic clay first rises below the London clay. At this point the section is as follows, beginning at the top:—

Vegetable mould	2 feet
Gravel	2
Green loam, identical with some of the London clay of Highcliff, in which green earth is as abundant as in some of the Shanklin beds	2
Flint gravel	4
Sand	3
Gravel	4
Sand of plastic clay	thickness unseen

The difference in the nature of the diluvium in this place is doubtless connected with the formation of the valley of the Stour and Avon; for it is the eastern slope of this valley which is here intersected by the coast section. The chines or small valleys between Christchurch Head and the mouth of Pool Harbour are hollowed out of strata composed of soft materials, as clay-

loam and fine sand. The size of the valleys is in general in proportion to that of the streams flowing in them, and their excavation appears referable for the most part, if not entirely, to the long continued agency of these streams. It is impossible not to draw this conclusion, when we observe the power exerted at present by several small rills, which have divided the cliffs in some places where their height is greatest, by perpendicular fissures or narrow ravines, the sides of which still remain vertical, because the water constantly undermines them and removes the loose sand, clay, and gravel.

XIX.—*On the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire.*

By Charles LYELL, Esq. F.R.S. F.L.S. F.G.S.

[Read June 2nd, 1826.]

IN the last volume of the Transactions of the Geological Society, there is a description of the strata in the cliffs between Lymington and Muddiford near Christchurch; and, in a section accompanying the Memoir, the extent of the different formations exhibited in this line of coast is laid down. Large collections of the fossils of these cliffs have been made since the days of Brander, who published an account of them in 1766; and many have paid hasty visits to the spot, for the purpose chiefly of procuring fossil shells. But it was reserved for Mr. Webster to discover and first make known, in 1822, the existence of a distinct freshwater formation on the Hampshire coast, corresponding with the lower freshwater formation in the Isle of Wight. I have examined these freshwater strata in minute detail, their order of superposition, and their organic contents, with a view of furnishing data to geologists, for comparing these beds with those of the opposite coast of the Isle of Wight; and also to decide the question, on which doubts were entertained by the author of the Memoir above mentioned, whether the upper marine formation occupies any portion of Hordwell Cliff.

In determining the names of the shells, I am indebted to the kindness of Mr. James Sowerby; without whose assistance in examining specimens of the marls brought from these cliffs, several of the organic remains would have been entirely overlooked.

The following is a list of the beds in the order of their superposition as they are seen rising from beneath each other with a gentle inclination to the east, as we proceed from the eastern extremity of Hordwell Cliff towards Barton Cliff. Their extent and position will be easily seen by referring to the annexed sketch. (See Pl. XXX. No. 2.)

1. Diluvial gravel composed of broken chalk flints with occasional layers of sand and marl, varying in height from 5 to 50 feet.

2. Fine white sand, sometimes containing in the lower part layers of light green marl frequently stained with iron, from 3 to 12 feet.

3. Green marls, which may be thus divided, beginning with the upper beds:—
   a. Greenish unctuous marl without shells, varying from 1 to 3 feet.
   b. Dark leaden-coloured greenish clay. Contains bituminized wood and numerous seeds or capsules of plants (figured Pl. XII. Geol. Trans. Part 1. vol. 1. 2nd series); and the following shells. Unio Solandri (Min. Con. tab. 517.). This shell is abundant, but in a very fragile state. The nacre of the shell is well preserved; sometimes, but rarely, it is found perfect with its brown covering. Helix lenta (Brander) in great abundance. Melania, in the lower part of the bed, in a very perfect state, a shell not yet described in any publication. The thickness of this bed, which is well seen at the Mine Way, is about one foot and a half.
   c. Green marl, with the same seeds as above; also containing unio Solandri, helix lenta, and melaniæ in abundance, and fragments of another conical shell (perhaps part of the spire of a lymnæa ?). The green marls containing melaniæ are found in the ruins of the cliff between the Mine Way and Hordwell-End-Lane, in large fallen masses; and the bed to which they belong will appear to be often repeated, unless great caution is used.
   d. Marl of a beautiful bright green colour, characterized by melanopsis carinata (Min. Con. tab. 523. fig. 1.); containing also helix lenta and planorbis lens (Min. Con. tab. 140. fig. 4.); also fragments of lymnæa fusiformis (Min. Con. tab. 169. fig. 2, 3.).
   e. Arenaceo-argillaceous marl dividing into laminæ, occasioned in some degree by exceedingly minute fragments of unio Solandri disposed in parallel layers, and resembling mica. The position of this sandy bed is not easily ascertained in the above group, in consequence of the ruined state of the cliffs. Unio Solandri occurs in this bed unbroken, and the seeds noted in 3. *b.*; also numerous valves of a small cypris of a yellow colour, in layers, as the cypris occurs in the Weald clay. Thickness of *c. d. e.* about 12 feet. Total thickness of No. 3. about 16 feet.

4. Sands and clays, which may be thus divided:—
   a. Greenish brown sand, 8 inches.
   b. Brown laminated clay, and bituminous dark clay with lignite, one foot and a half thick.
   c. Marls of various shades of green, 12 feet.
   d. Bright green marl; in the lower part, mya gregarea (Min. Con. tab. 363.) in great numbers and very perfect, lying on their sides parallel to the planes of stratification: this bed is about one foot and a half thick. Thickness of No. 4, about 15 feet.

5. *a.* Calcareous marl, sometimes slightly indurated, consisting of aggregated shells, planorbis rotundatus (Brard.), and lymnæa longiscata (Min. Con. tab. 343.), in a very fragile state and generally broken. A small species of lymnæa (columellaris Sow. Min. Con. tab. 528. fig. 2.), occurs, rarely; also L. fusiformis. In some parts, as about 200 yards East of Hordwell-Lane-End, where it first rises, this bed contains gyrogonites (chara Medicaginula) in abundance. Although this bed is only from six to eight inches thick, it is very conspicuous from its light colour and the black bed of carbonaceous matter immediately below it.

b. Black carbonaceous clay with lignite, from one to five inches. Thickness of No. 5. about 1 foot.

6. *a.* Green unctuous marls without shells, four feet. In some places, as near Long-Mead-End, this marl hardens into green stony concretions, which, when exposed, acquire a ferruginous colour, and are seen projecting from the cliff or strewed along the beach.

b. Green arenaceous marl, in some parts passing into a pure white siliceous sand. The two shells which occur in great abundance in this stratum are mya plana (Min. Con. tab. 76. fig. 2.) and a species of potamides. Besides these are found melanopsis brevis, two species of cyclas, a neritina, fragments of helix lenta (Brander), a small cylindrical serpula, and also shining lozenge-shaped scales of fish? Gyrogonites also (chara Medicaginula) abound in some of the sandy portions of this stratum in Beacon Cliff. This bed is about two feet and a half thick.

c. Beds of pure white sand and argillaceous sand. These are characterized by a layer of sand filled with a potamides like P. margaritaceus (Min. Con. tab. 339. fig. 4.), accompanied by mya plana; the latter in a very perfect state with both valves. Hardened blocks of this sand lie on the beach, containing the potamides in abundance. A species of mytilus also occurs (M. Brardii, Min. Con. tab. 532. fig. 2.), and one from hence has a small serpula attached, which is cylindrical, with two ridges. These beds are from 8 to 10 feet in thickness. Melania conica (Min. Con. vol. 6, p. 60.) (bulimus conicus Brard.) is also abundant with the above. Total thickness of No. 6. about 15 feet.

7. *a.* Light green marl, containing mya subangulata and a planorbis, 3 feet thick.

b. Dark arenaceous bed, sometimes argillaceous. In this are found helix or paludina lenta (Min. Con. tab. 31. fig. 3.), mya subangulata*, melanopsis brevis (Min. Con. tab. 523. fig. 2.), a small planorbis, a new species of ancylus, A. elegans (Min. Con. tab. 533.); with many minute shells, apparently the young of some of the preceding: also small smooth shining black capsules, of a plant nearly spherical, hollow, lined with a membrane, the integument composed of minute cells. 2 feet thick.

c. Light green marl with a layer of bluish sandstone, 4 feet.

d. Carbonaceous clay and lignite, 6 inches.

e. Light green marl, 2 feet.

f. Carbonaceous black clay, 6 inches.

g. Sandy loam, 3 feet.

h. Reddish brown clay, 3 feet.

i. Light green loam; in lower part univalves (helix lenta?) and gyrogonites (chara Medicaginula), 7 feet. Total thickness of No. 7, about 22 feet.

8. *a.* Green marl; bivalves in the upper part, 5 feet.

b. Coal-black carbonaceous clay and lignite, 6 inches.

c. Black mould resembling bog-earth, 6 inches.

d. Ferruginous clay. In this is a species of cyclas, the same as one of those noted in 6 *b.*, fragments of a mytilus resembling crenatus, mya subangulata, and fragments of an univalve, 6 inches.

---

* Mr. J. Sowerby considers it not improbable that this shell may be the young state of mya plana.

e. Light bluish gray marl with vegetable impressions, 1 foot.

f. Black carbonaceous clay and lignite, 6 inches.

g. Green clay, 1 foot. Total thickness of No. 8. about 9 feet.

9. White siliceous sand, without shells, rises near Long-Mead-End and extends through Beacon and Barton Cliffs to the middle of Highcliff.

Besides the organic remains above enumerated, scales of tortoises have been found by some collectors*. They occurred either in the group of strata No. 3, or in that termed No. 4, of the above section. Gyrogonites also have been found in abundance in the same part of the cliff, though I did not observe them myself. In No. 3, the seed-vessel called by M. Brongniart *carpolithes thalictroides* † has been procured. In No. 4, teeth of a crocodile or some saurian animal, and lozenge-shaped scales of fish?

On reviewing the strata described in the above section, and their contents, the following observations occur.

1st. No portion of the upper marine formation exists anywhere in this part of the Hampshire coast. The uppermost beds of the series in Hordwell Cliff, so far from indicating a passage into the upper marine formation, contain organic remains, both animal and vegetable, exclusively belonging to freshwater genera. The shells referred to by Mr. Webster as cerithia, occurring in fallen blocks along the shore, belong to the genus Potamides of Brongniart, and the stratum in which they abound occupies a middle place in the series. Cerithium is a marine genus; but the potamides, of which some species still exist in a recent state, inhabit rivers, or at least the mouths of rivers ‡.

2ndly. The extent of the freshwater formation is somewhat greater than had been supposed, as it is continued in Barton Cliff to nearly opposite the village of Barton. The lower beds of the series there exposed contain in parts gyrogonites and freshwater shells.

3rdly. The fine white siliceous sand of Beacon and Barton Cliffs must, till some reason be shown to the contrary, be referred to the freshwater formation: for it will be seen by the above description, that two beds of a similar fine white sand occur associated with the freshwater strata in Hordwell Cliff. It is therefore clear, that when this series was deposited, all the circumstances existed which were required for the formation of such sand; whereas nothing similar is found connected with the London clay in any part of England. The lower freshwater formation must thus be considered as extending throughout Barton Cliff to about the middle of High Cliff.

* The entire shell and bones of a tortoise have lately been found in the lower freshwater formation near Thorness Bay, in the Isle of Wight.

† Cuv. Oss. Foss. tom. ii. edit. 2de. Pl. XI. f. 5.

‡ Cuv. Règne Anim. tom. ii. p. 438.

4thly. The strata of Hordwell Cliff correspond with those on the opposite side of the Solent, particularly with the lower freshwater beds between Yarmouth and Gurnet Point: where, as Professor Sedgwick observes*, they lose the appearance of an indurated calcareous marl, and are not unfrequently of a bright green colour, and preserve their continuity for a great extent. "In a part of the coast between Yarmouth and Hampstead Cliff," he adds, "the beds are brought out from one under another in a long succession. The whole formation is subdivided by almost innumerable layers of fossil shells, which follow the planes of stratification. The beautiful preservation even of the minutest characters both of the bivalves and of the univalves, and still more the arrangement in distinct families, afford a proof not short of demonstration that the whole system has originated in a tranquil deposition." Professor Sedgwick's description is equally applicable to the strata on the Hampshire coast; and the genera of shells enumerated by him are the same, as far as they go, with those which I have mentioned. Although no doubt can be entertained that the strata of Hordwell Cliff belong exclusively to what has been termed in the Isle of Wight the Lower Freshwater Formation, yet it may be a question whether the organic remains are not of a mixed nature, some few examples presenting themselves of shells belonging to marine genera. Thus a small mytilus occurs in two of the beds, and, in two instances, a small serpula; the latter shell was found also by Professor Sedgwick in Hampstead Cliff† in the Isle of Wight. But although these latter testacea may have required salt-water, they may very probably have inhabited the estuary of a river within the influence of the tides; for the whole assemblage of organic remains is so precisely similar to that which characterizes recent freshwater deposits, and there are so many proofs of tranquil deposition, that we cannot suppose them to have been all washed by the violence of floods into the sea.

The plentiful exuviæ of the cypris‡, as well as the gyrogonites§, are positive indications of the freshwater origin of this formation. The small number of genera and species to which the shells are referrible, though the

* Ann. of Phil. for 1823, vol. iii. p. 347.

† Sowerby Min. Con. No. 91, description of Tab. 527.

‡ Lamarck observes in his work "Animaux sans Vertèbres," that these microscopic entomostraca change their skin and shell at the same time. They inhabit the fresh and stagnant waters of marshes and ditches, and swim swiftly. Vol. v. p. 124.

§ These fossil seed-vessels have been found by some collectors in Hordwell Cliff in great abundance, in some of the fine white sands. The fine sand of the Thames, used for covering the floors of kitchens in London, is often filled in a similar manner with the seed-vessels of recent Charæ. The integument is so tough that the spiral ridges on the surface retain their sharpness as in their fossil analogues, uneffaced by the attrition of the sand.

individuals are in great abundance, is a circumstance characteristic of recent freshwater deposits: whereas shells, whenever they occur plentifully in ancient marine formations, belong to a variety of distinct species; and, from what we know of the living testacea of our seas, we may conclude that this is the case in submarine strata now in the act of forming. The almost entire absence, amid such a multitude of organic remains, of decided marine productions, is, when coupled with the other circumstances, a strong negative fact. Upon the whole, there are sound geological reasons, both in this and in other instances, for extending the term *Freshwater Formations* to deposits which may have been formed at the mouths of rivers, and for no longer restricting it to such as have originated in inland lakes.

XX.—*On the Coal-field of Brora in Sutherlandshire, and some other Stratified Deposits in the North of Scotland.*

By Roderick Impey Murchison, Esq. Sec. G.S. F.R.S.

[Read January 5th, and February 2nd, 1827.]

THE peculiarities of the Brora coal-field had excited considerable interest among geologists, a few specimens of its more remarkable fossils having been occasionally sent to England. My attention was particularly called to this tract, by the Rev. Dr. Buckland and Mr. C. Lyell, who having visited Brora in the year 1824, expressed an opinion that the strata there were wholly unconnected with the coal-formation below the new red sandstone, and were in fact the equivalent of part of the oolitic series*. I was thus led to devote last summer to an examination of the district: and for the purpose of comparing its structure with that of certain parts of England and Scotland, which appeared to have the same physical characters, I previously surveyed the coast of Yorkshire, from Filey Bay to Whitby, comprising the coal-tract of the Eastern Moorlands; and afterwards some of the islands of the Hebrides. I

* The only printed notice of the Brora coal, with which I am acquainted, is contained in a general account of the Clackmannan and other Scottish *coal-fields* by Mr. Bald (Memoirs of the Wernerian Society, Edin. vol. iii. p. 138.) But it ought to be mentioned that a manuscript sketch of this tract has been read before the Philosophical Society of Inverness, by Mr. Anderson of that place; and if the avocations of this gentleman had permitted his examining analogous deposits in England, the present memoir might have been anticipated.

On the Yorkshire coast I had the great advantage of being accompanied by Mr. William Smith, whose accurate acquaintance with the different oolitic formations has enabled him to detect in Yorkshire, nearly all the beds belonging to that series in the south of England. Professor Sedgwick had established the general relations of these strata in a paper published in the Annals of Philosophy for May 1826; and the Rev. Wm. Vernon has since pointed out the existence, along the south-western boundary of the Wolds, of several of the beds discovered by Mr. Smith near Scarborough (Annals of Phil. June 1826.) In procuring illustrative fossils, with a view to comparison, I was kindly assisted by Mr. Williamson of Scarborough, a most accurate and zealous collector. For a detail of the order of beds in this district, see p. 297, note †.

now submit to the Society the result of this comparison, with some of the illustrative fossils of each tract, accompanied by a map and sections.

I shall commence with a description of that district which was the prime object of my research, and which is of the greatest importance in its mineral contents. The Brora coal-field forms a part of those secondary deposits which range along the S. E. coast of Sutherlandshire, occupying a narrow tract of about 20 miles in length, and 3 in its greatest breadth. The strata connected with it begin to rise from the sandy shore between Golspie and Dunrobin, and extend to the mountain called the Ord of Caithness. For the purposes of geological illustration, this tract may be said to be divided into three semi-elliptical valleys, separated from each other by the successive advance to the coast of the interior mountain range, which in retiring, forms their W. and N.W. boundary. These valleys diminish in size from S.W. to N.E., and in this distribution they stand thus:—

1st. Brora.
2nd. Loth.
3rd. Navidale.

The first is bounded on the S.W. by the mountain of Ben-a-Bhraggie, and on the West by the hills of Uppat, Loch Brora, and Clyne; all of which are composed of that red conglomerate which covers so large a portion of the North-eastern Highlands. Here it is formed of fragments of all sizes derived from the adjacent and more ancient rocks, passing into and alternating with a fine-grained red sandstone, occasionally schistose, highly micaceous, and variegated in colour. It is generally horizontal on the summits of the hills, or deposited on their sides with a slight inclination to the East. It is quarried as a building-stone at the base of the Craigton Hills, and the more fissile schistose beds on the summit of Ben-a-Bhraggie have even been employed as roofing-slates. On the N.E. of Loch Brora this red conglomerate gradually passes inland in a N. W. direction, forming the cap of some of the higher mountains. The low country of the coast is thenceforward bounded by an unstratified granitic rock, which is first seen near the church of Clyne, whence it sweeps down to the coast at Colyburn, there interrupting the stratified beds hereafter to be described, and thus inclosing the vale of Brora. Again retiring from the coast it continues to mark the interior boundary of the vales of Loth and Navidale, separating them by its advance at Portgower, and terminating the secondary series at the Ord of Caithness. This rock is throughout the greater part of its extent composed of reddish felspar and gray quartz, which are more or less accompanied by a decomposed green substance which may have been mica. It is always unstra-

tified, in some localities fine-grained, compact, and of a deep red colour: in others a coarse aggregate of pale-coloured felspar and gray quartz; whilst, at the points of junction with the secondary strata, it is usually in a decomposed state. In external character as well as in that internal structure which resists a fresh fracture, it strongly resembles the syenite of the Malvern Hills, (described by Mr. Leonard Horner,) to which it presents a further analogy by splitting under the hammer into cuboidal fragments, the interstices of which are sometimes coated with oxyd of iron.

The surface of the greater portion of the valleys is covered with vast quantities of diluvial gravel, principally derived from the adjacent mountain ranges, and diversified with numerous conical and tabular eminences. The strata beneath this diluvium are only occasionally visible; sometimes in low cliffs upon the coast, at other times where the plains are intersected by a stream; and an acquaintance with many of the beds, is only to be acquired by an examination of the reefs exposed at low water. (See Pl. XXXI. fig. 1.)

The relations between the superior strata and the red conglomerate cannot be observed in the Brora district; because the lowest beds of the former dipping under the sea, are considerably above the base of the series, which will elsewhere be described, in contact with the red conglomerate on another part of the coast.

The junction, however, between the granitic rock and the superior strata is seen in several places along the interior boundary of the valleys, where the sandstone and shale rest highly inclined or dislocated upon the edge of the mountain range. A striking example is afforded near Clyne church; where a stream forcing its way down the mountain side has cut several deep chasms, exposing alternations of stratified primitive rocks, nearly vertical and much contorted, consisting of quartz-rock and chloritic and micaceous schist, which last is accompanied by small portions of specular iron and galena. The granitic rock is here and there seen in the bed of the rivulet; whilst, at the base of this defile, the sandstone and shale of the coal-field rising gradually from Inverbrora, are suddenly elevated in the proximity of the same unstratified rock, which affects the primitive strata in the higher part of the ravine. (See Section on the line C, D. Pl. XXXI. fig. 1, and also fig. 2.)

I now proceed to detail more particularly the structure of the first of the three valleys before mentioned.

The district of Brora is about eight miles in length from Golspie to Colyburn, and about two miles and a half in its greatest breadth, where it is intersected by the river Brora; which flowing in a north-easterly direction from the loch of the same name, cuts through the diluvium of the plain, and pre-

sents on its northern bank, for nearly a mile and a half above its mouth, a broken succession of low cliffs, consisting of yellow micaceous sandstone, and dark coloured micaceous shale with belemnites, &c. At the first emergence of these cliffs, the river quits them and bends to the south, incircling in its course a trough of low land called the Pool, bounded on the south by table-shaped hillocks covered with diluvium. It then enters a narrow gorge, where the sandstone and shales are exposed on each bank to the height of 30 or 40 feet, and are visible from thence without interruption during the remainder of its course, which continues for about half a mile.

The highest eminences in the vicinity are the rounded hills of Braambury, situated a mile and a quarter from the sea. A portion of their surface, unlike that of every other elevation near them, is bare of diluvium; and the exposure of the valuable freestone of which they are composed, has led to the extensive quarries now worked there by the direction of the Marquess of Stafford*. Though probably not less than 200 feet above the level of the sea, with a dip conformable to that of the inferior strata containing coal, this stone is not to be traced beyond the hills where it is quarried, and may therefore be considered as an isolated portion of a stratum, the continuation of which has been removed, probably by denudation.

The exterior surface of this rock is channelled into undulating grooves, and the dip of the beds is easterly, at an angle of 25° to 30°. Where quarried for use they consist of a remarkably white quartzose sandstone, without admixture of iron or any discolouring matter. In other beds the cement and grains are united into one homogeneous quartzose mass, the thinner layers of which are of so compact a structure as to have been used for gun-flints: the extreme whiteness of some of these beds is strongly contrasted with small black portions of lignite imbedded in them. Numerous casts of fossils abound, with large stems of plants; some of the former, particularly three new species of pecten, are remarkable for the sharpness and minuteness with which they have retained the impressions of the shells, it being difficult to imagine how the siliceous grains of which this rock is composed, could be united into so uniform a paste. All the fossils now presented to the Society for the illustration of this memoir have been examined by Mr. J. Sowerby; and with his kind assistance I have annexed a tabular view, referring them to their analogues in England.

The freestone of Braambury and Hare Hills is in some places overlaid by

* This white freestone is in actual use for the construction of the interior of London Bridge, for which purpose it seems admirably adapted by the compactness of its structure and the vast size of its blocks.

a rubbly limestone, an aggregate of shells, leaves, stems of plants, lignite, &c. The prevailing fossils of this bed and the casts in the freestone are referrible to the calcareous grit or base of the coral rag of the oolitic series of England: viz. ammonites vertebralis, A. perarmatus, A. cordatus, the pecten of Marcham Field, Oxfordshire; gryphæa bullata, G. nana, &c.; Lucina crassa, modiola bipartita; most of which occur in the calcareous grit on the summit of Scarborough cliff*. It is remarkable, however, that the bivalve hitherto called the Venus of the Portland stone is found in the upper beds at Braambury Hill. It proves to be a cardium, and has at length been figured as C. dissimile, in Min. Con. tab. 553. (For further details see the Table of Fossils.)

A similar transition takes place at Abingdon, from a rubbly limestone into a siliceous rock, where many of the fossil shells are of the same genera and species as those now described.

If this sandstone of Braambury be not exactly similar to any rock in England, there is a complete identity between its fossils and those of the calcareous grit of the N. E. coast of Yorkshire; and the inferior strata in both cases have a close mineralogical resemblance. At the southern edge of the Eastern Moorlands, the lowest beds of the coral rag formation lose entirely their calcareous oolitic structure, and form lofty escarpments of white and yellowish sandstone: these are succeeded by shale containing belemnites and ammonites, from beneath which the great coal and sand formation rises to the North. A like succession takes place at Brora: in descending from the Braambury quarries to the coal-pit, some of the strata are obscured by diluvium; but these it may be inferred are the equivalents of those formations which intervene in Yorkshire between the calcareous grit and the strata containing coal; because beds with the fossils of those formations are exposed in various reefs along the coast of Sutherland, and the micaceous sandy beds with thin courses of shale, on the banks of the river above the coal-pit, represent another part of the same series†.

The coal-pit now in work is situated at the base of the sand and shale cliffs

* The beautiful casts of several new species of pecten in the quartzose sandstone of Braambury, are very similar to those of the calcareous grit of Malton, and Scarborough, recently figured in Mineral Conchology, tab. 543.

† On the coast of Yorkshire the strata appear in the following descending order, from Filey Bay to Whitby. 1. Coral rag. 2. Calcareous grit. 3. Shale with fossils of the Oxford clay. 4. Kelloway rock (swelling out into an important arenaceous formation). 5. Cornbrash. 6. Coaly grit (of Smith). 7. Pier stone (according to Mr. Smith, the equivalent of the great oolite). 8. Sandstone and shale with *peculiar* plants and various seams of coal. 9. A bed with fossils of the inferior oolite. 10. Marl-stone? 11. Alum shale or Lias.—All the above strata are now identified by abundant organic remains.

near the gorge, through which the river flows, and the shaft is sunk to the depth of 230 feet*. An account of the beds cut through in 1811 is annexed in the Appendix, but unfortunately the fossil remains were not at that period scientifically distinguished. One of these beds only is now exposed to view on the sides of the shaft, and is a compact calcareous ironstone, very similar to that which is so largely distributed throughout the coal-formation of the Scarborough coast. The first beds which are open to examination, form the roof of the coal, and are about 2 feet 7 inches in thickness: the upper part is an aggregate of fossil shells, cemented together with calcareous matter and quartzose grains: the lower part is made up of a compressed assemblage of leaves and stems of plants, crossing each other, and passing into shaly coal.

The broken and decomposing shells are mixed with carbonaceous matter, grains of quartzose sandstone, much pyrites, some crystals of sulphate of iron and selenite. I refer to the tabular view (p. 318.) for a detail of all the fossil shells; remarking that this bed alone has afforded 24 different species, of which 16 are well-known fossils of the oolitic series of England: amongst the hitherto undescribed shells, Mr. J. Sowerby has upon this occasion named and figured two species of the new genus pholadomya, one ammonite, one cardium, and one sanguinolaria. (Min. Con. tab. 545, 546, 548, 549.)

Many of the fossils of this bed are analogous to those of the pier stone near Scarborough, which there overlies the main coal-seams: the Gervilliæ, trigoniæ, univalves and ostreæ of these two beds, so far removed from each other, are identical; and perhaps the most remarkable feature in this coincidence is, that a bivalve not yet figured, (which Mr. Sowerby is inclined to refer to the new genus Pullastra,) is most abundant at Brora, and likewise characterizes all the strata above the coal on the N. E. coast of Yorkshire.

I am indebted to my friend Mr. König for the following account of the plant from the roof of the Brora coal, which he has identified with one of the fossil vegetables collected by me on the Yorkshire coast†.

"The vegetable remains in sandstone, slate-clay and clay-ironstone from the

* The section of a shaft, subsequently sunk at the engine pit 780 yards distant from the above, is also placed in the Appendix. This account as revised by Mr. Bald, was given by that gentleman in the Memoirs of the Wernerian Society. By comparing these two sections, it will be seen that the beds vary much less than might have been expected, when the distance between the shafts is considered.

† This plant has been figured in a work containing much valuable detail, viz. Messrs. Young and Bird's "Survey of the Yorkshire Coast:" but its botanical characters never having been scientifically given, I avail myself of Mr. König's description, and have annexed drawings of it, as seen in the sandstone of Yorkshire and the coal-shale of Brora. (See Plate XXXII.)

oolitic formation in the vicinity of Whitby, appear to me distinct from any which are known to occur in the true coal-formation. Most of these plants are undescribed, and deserve to be characterized from more perfect specimens than those before me.

"In most of the fragments of the slate-clay which I have seen, two or three distinct plants, or rather parts of plants, might be distinguished. One of these appears either in the shape of carbonaceous expansions exhibiting acute regular furrows of various lengths, gradually diminishing in width, and running out into linear grooves; the intermediate space, in the more perfect specimens, being marked with depressed dots; or in the shape of elevated rays or ribs having a pretty acute ridge and gradually tapering, from the width of $\frac{1}{10}$ of an inch, into a fine, more or less lengthened, raised line. The latter appearance is produced by a counter-impression from the grooved expansions. Together with these are seen well defined composite leaves: they are bipinnated, with pinnatifid ovate leaflets, having veins proceeding from the base, without a distinct mid-rib. They might, on account of their regular juxtaposition, be considered as having belonged to the abovementioned grooved and radiated expansions, could not the origin of these latter be traced to an order of plants which does not seem to admit of such a foliation; I mean, the arundinaceous vegetables found in the sandstone above the slate-clay. These consist of portions of jointed stems from one to two inches in diameter, and of various length; they are either cylindrical or collapsed and flattened; their joints, from one to three inches distant from each other, appear as bulging rings, and, if broken at the places of junction, exhibit traces of a dissepiment, which also appears to be indicated in some specimens by a slight depression round the middle of the projecting ring. The surface of the cylindrical fragments is nearly smooth and even; but at some distance from the joints fine grooves appear, which are widest near and on the tubercular swelling, where they assume the form of equidistant narrow slits, each formed by two planes meeting under a rather obtuse re-entering angle. Above the articulations, in some specimens, may be observed traces of a single impression or cicatrix; those which are not furnished with this may possibly belong to the root of the vegetable.

"Now, on comparing many of the grooved joints of these reeds in the sandstone with the ribbed leaf-like expansions in the shale, it will be found that there is no difference between them, except that in the former, though reduced to a thin film of coal, the shape of the stem has been more or less preserved by the hardened sand in their interior; while in the latter the carbo-

naceous rind has yielded to some external force, and adopted the form under which alone it is observed in the clayey mass.

"I should also mention that in these specimens of shale some other vegetable parts are occasionally observed, in the shape of small sub-triangular or inversely-cordate carbonaceous plates, which seem to have been membranaceous involucra, connected with the inflorescence of a plant. Those botanists who take it for granted that the composite leaves above alluded to are those of ferns, and that the reed-like stems are related to Equisetum, will of course be quite satisfied that the plates in question can have nothing to do with either. I cannot disprove that supposition.

"With regard to the coal from Sutherlandshire, I am (in corroboration of Mr. Murchison's views respecting its geognostic relations) decidedly of opinion that the above reed-like striated plant must have largely contributed towards the formation of that variety of coal. Its original structure is indeed nearly obliterated, but is nevertheless recognizable in the regular striation on the rifts; and in one specimen I have seen, it is partially exhibited with the same distinctness as in the reeds themselves.

"The plant under consideration may possibly be referrible to the same natural order with Equisetum, but it cannot be considered as a congener of the striated, reed-like fossils which have been comprised under the faulty name of *Calamites;* it is distinct from them by its peculiar striation, by the solitary impression above the joints, placed in such a manner as to indicate distichous alternating branches, and by the very striking callosity at these joints, which latter character has suggested the generic name of *Oncylogonatum.*

"The following phrase may, in the present state of our knowledge of this plant, serve both for its generic and specific character:—Caulis cylindricus articulatus, articulis annulato-gibbosis, gibbis internodiisque longitudinaliter sulcatis, sulcis acutis.—Species: *O. carbonarium.*"

From the coal-shale composed of the above plant, the next transition is into a purer bituminous substance approaching to jet, which constitutes the great bed of coal. This is from three feet three inches to three feet eight inches in thickness, and is divided nearly in the middle by a thin layer of impure indurated shale charged with pyrites, which, if not carefully excluded from the mass, sometimes occasions spontaneous combustion * upon exposure to the

* Inattention on the part of the workmen in the year 1817, in leaving a large quantity of this pyritiferous shale to accumulate in the pit, occasioned a spontaneous combustion, which was only extinguished by excluding the atmospheric air: the coal-pit was closed in, and remained unworked during four years. I have just learned (Feb. 1827) that fires have again broken out in the pit.

atmosphere; and so much indeed is that mineral disseminated throughout this district, that the shales might generally be termed "pyritiferous."

Although 14 or 15 slight dislocations are connected with the pit now in use, the present level was driven nearly 900 yards before the great fault was met with, which limits the coal-field upon the West, where lower beds containing nodules of blue limestone with septaria, are brought up near the salmon cruives. It is probable that from this place have been derived those boulders which are seen at the mouth of the river Brora, and which so resemble the cement stones of the alum shale at Whitby. Some of these faults are occupied by a white quartzose, and highly indurated sandstone, having a conchoidal fracture. Sinkings subsequently made below the working level, passed through beds of bituminous shale for upwards of 90 feet, when sandy clays of a loose structure stopped the works by occasioning a great influx of water; and therefore the whole depth of the sand and shale below the coal has never been ascertained.

The beds in contact with the granitic range are about one mile and a half distant from the coal-field, if the application of this term be restricted to that area in which the mineral has been discovered: indeed all attempts to work coal resting upon granite, would be impracticable, on account of the dismemberment of the strata which invariably accompanies such junctions.

For an analytical view of the chemical changes in the various lignites, from those of the highest formations down to the more perfectly bituminized substances similar to this under consideration, I refer to the Works of Dr. MacCulloch. With respect to the Brora coal, the purer part of it differs in no respect from the coal of the carboniferous series when subjected to chemical analysis; but it offers a mineralogical distinction upon being pulverized, assuming like all lignites a red ferruginous tinge, and thus differing from the true coal which works into a black powder *. The laminæ between the seams of the latter are generally coated with pure carbonaceous matter, whilst those in the Brora coal are occupied by bituminous shale. It may be considered one of the last links between lignites and true coal, approaching very nearly in character to jet, though less tenacious than that mineral; and when burnt, only slightly exhaling the vegetable odour so peculiar to all imperfectly bituminized substances. The fossil remains of shells and plants prove the Brora

* The same test does not strictly apply to *all* specimens of the coal, either at Brora or on the east coast of Yorkshire, which, although it occupies the geological place of lignite, is in some places not to be distinguished mineralogically from ordinary coal.

coal to be analogous to that of the Eastern Moorlands of Yorkshire, although the extraordinary thickness of the former, compared with any similar deposit of the latter, (which never exceeds from 12 to 17 inches,) might have formerly led to the belief that it was a detached and anomalous deposit of true coal, rather than a lignite of any of the formations above the new red sandstone: such misconception might more easily arise at a period when the strata were not identified by their fossil organic remains.

An epitome of the history of these coal-works is given in the Appendix, p. 323 *.

Coast Section.

I will now briefly describe the appearances on the coast, proceeding from S.W. to N.E.; as the beds exposed at ebb-tide, and in the low-cliffs, best explain the general stratification of the district.

The shore between Loch Fleet and Golspie consists exclusively of blown sand; and although the interior to the westward is very soon occupied by the red conglomerate, there are no traces of it upon the coast.

The first appearances of those strata which alternate throughout the Brora district, are seen at low water near Dunrobin Castle, where calcareous sandstones are succeeded by beds of pebbly calciferous grit, (upon which the pier is built,) and which are overlaid by shales containing limestone with fossils. The coarser varieties of the calciferous grit have in a remarkable degree that structure which is so frequently observable in all concretionary rocks; the planes of fracture coinciding with the cleavage of the grains of which the mass is chiefly composed, and exhibiting a silky lustre in one direction. The beds on this part of the shore occupy from 400 to 500 yards in breadth, with a N.E. dip of about 20° or 25°. The grits are overlaid by sandstone and micaceous shales, the latter containing numerous and flattened impressions of ammonites and small belemnites with indications of coaly matter. These are succeeded by black and white sandstone and shale, including a dark coloured limestone, the latter being an aggregate of fossils, including gryphæa nana, terebratula inconstans, serpula, pullastra, plagiostoma, pecten, &c. &c. The highest shales contain a dark blue limestone with septaria and very small sack-shaped pyritous nodules.

* For these documents and much kind assistance during the prosecution of my inquiry, I am indebted to the Marquess and Marchioness of Stafford, to whom belong all the tracts of country laid down upon the map; and their agent at the Brora works, Mr. Robertson, was most zealous in aiding my examinations.

The fossils of these reefs are for the most part referrible to the Oxford clay, and in general aspect the micaceous shales strongly resemble those already described in that part of the series on the N. E. coast of Yorkshire. It is probable, as I have elsewhere stated, that these same beds occur immediately below the quarries of Braambury, and would there have been seen overlying the sandstone of the cliffs, had they not been obscured by diluvium. These ledges of rock at Dunrobin are quite detached, and the sandy beach is resumed to the N. E., the eminences upon which the castle stands being diluvial, although the existence of sandstone below with subordinate coal has been ascertained by borings in that neighbourhood, and beds of shale basset out near the road from thence to Inverbrora.

A low coast of blown sand extending for about a mile towards the N.E. leads to the cliffs, which, in rising, exhibit a yellowish white micaceous sandstone; and, at this place, coal has been partially worked, probably a higher seam than that at Inverbrora.

At Strathsteven, the sandstone is quarried to the depth of 30 feet: it is here of a pure white colour, very friable when first raised, but hardening by exposure, and then acquiring partial ferruginous stains on the surface. In mineralogical structure it is identical with many beds of the great sandstone formation of the Eastern Moorlands; and thin courses of coal, differing somewhat in structure as well as in position from that of Inverbrora, indicate that here, as upon the Scarborough coast, there are several seams of that mineral. These quarries are valuable from their contiguity to the sea, and the facility with which the stone is worked. The cliff lowers gradually from hence, into trivial hillocks covered with blown sand, at the links of Inverbrora, where are still the remains of several old coal-pits. (See Appendix.)

The reefs which are exposed along the coast between Strathsteven and Inverbrora, with the exception of one fault, rise to the W. N. W. being prolongations of the strata of the Inverbrora coal-field; the beds of which being thus shown to be conformable throughout so considerable a space, their dip and inclination, viz. E. 25°, may be assumed to be those of the deposit. Coal has occasionally been worked at low water near the old salt-pans under a bed of fossils, agreeing precisely in contents and thickness with that which has been described as forming the roof of the coal at Inverbrora. The fossils are here found in a high state of preservation, and, in their ferruginous aspect, strongly resemble those of the pier stone of Scarborough. This bed, like that which overlies the coal at the Inverbrora pits, is covered by a suite of sands and shales, the latter containing flattened ammonites, and a large variety of the belemnites sulcatus. (Geol. Trans. 2nd ser. vol. ii.

Pl. VIII.*) These are overlaid by an indurated white quartzose sandstone, which runs out into a long *scar* from the south bank of the river Brora. The stratification of the coast reefs at Ardasie Point on the north bank of the river is indistinct, and there appears to have been a great subsidence from thence, by which the highest beds of the district have been depressed below the level of the sea: hence no rocks are to be seen throughout the sandy bay north-east of the river Brora, the low grounds between it and Clynemilltown being covered with blown sand and gravel.

At Kintradwell are the first appearances of beds differing from any previously mentioned: some of these resemble the cornbrash limestone, and others the forest marble; the prevailing fossils being the avicula inequivalvis and the terebratula inconstans. One of these beds of shelly limestone is overlaid by shale in a low hillock on the shore, and below it are reefs of bluish calciferous grits containing a few fossils, among which the nerita lævigata was observed. These grits are traversed by a vein two feet and a half wide, in texture resembling quartz-rock and having a conchoidal fracture: the tilting of the strata in opposite directions at this point indicates some powerful disturbing cause. After a short interval of low shore, the sandstone and shale above the beds of shelly limestone form cliffs, near Colyburn, higher than those of any other part of the Brora coast. Here the granitic rock advances from the mountain range, occupying both sides of a precipitous ravine; and the secondary strata near it are much dislocated: the sandstone is in some places indurated, and accompanied by brown hæmatite; and porcelain clay (Kaolin) is dug in the cliff, probably derived from the decomposition of felspar. This advance of the mountain range forms a natural division between the vales of Brora and Loth.

Loth.

This vale is about six miles in length from S.W. to N. E., and varies in breadth from half a mile to one mile and a half. It is trough-shaped: the strata, which are highly inclined against the mountains of the interior, sink in the centre of the vale, and again rise on the exterior into low hills towards the sea. This coastward rise of the beds is apparently owing to the proximity of the granitic rock, which is here and there seen through the accumulations of blown sand. In the lowest or central part of the valley, black shale

* I have the authority of Mr. Miller, who has examined my specimens, for stating that the variety of B. sulcatus from these shales at Brora is identical with the belemnite of the Oxford clay.

is at present exposed in cutting drains, but the surface of the whole is partially covered by hillocks of diluvium.

At the mouth of the Loth-beg-burn, the cliffs on either side consist of black and white soft sandstone in very fine laminæ, and much carbonaceous matter is there visible in the underlying shale. At Crachaig Point the sandstone is of a coarser structure, and, in the sandy shale of the shore beyond that place, I found a large mass of a singular variety of a black carbonate of lime.

At Kilmot the shelly limestone first noticed at Kintradwell re-appears: here the beds dip in opposite directions and are highly inclined, owing probably to the proximity of the granitic rock. At Kilgour Point the reefs consist of the shelly limestone and grits, and the coast hills increasing in height are composed of shale occasionally seen through a cover of diluvium, and particularly at the mouths of several small streams between this and Portgower. The same order of superposition is apparent throughout the coast from hence to Navidale, wherever the superior strata are not obscured by diluvium; the shelly limestone and calciferous grit being the lowest rocks, and the shale the highest. Hence, if the former be the equivalent of cornbrash and forest marble, the latter may represent the Oxford clay.

The finer portions of the shelly agglomerate are burnt for lime at Portgower, Helmsdale and Navidale. At these places it is a mass of broken shells, agglutinated by an impure calcareous paste, and forming beds from a few inches to two feet in thickness; besides the terebratulæ and aviculæ mentioned at Kintradwell, there are found in it univalves, ostreæ, and other shells; with echinital spines, flustræ, &c. These remains are intermixed with abundant minute portions of black lignite, the fossil beds are frequently separated from each other by thin micaceous sandy shales, and the whole are in general based upon bluish calciferous grits. Near the limekilns at Portgower, the dislocations are most remarkable; the dip changing in the space of a few yards from an angle of 25° to one of near 70°, and the line of direction being as suddenly altered from E. to N. In consequence of the powerful disturbing forces which have been in action, some of the beds most affected here and along the shore to Kilmot, are made up of portions of shale and sandstone mixed with the shelly limestone, thus forming a conglomerate, of which more will be said hereafter. (See Map, Pl. XXXI: Portgower.)

At a short distance to the N. E. of that place the sandstone and shale, with a bed containing some imperfect fossils, are exposed in the coast hills, and much dismembered by contact with the granitic rock. In the centre of a wild ravine stands a conical hill, at the base of which two mountain torrents

unite. The lower part of this cone and bed of the stream are composed of the granitic rock; while the sides are covered by fragments of sandstone and shale, derived from the beds which rise from the ravine. (See Section, Pl. XXXI. fig. 2.)

It may now be remarked that the uniformity of dip which prevails in that part of the district of Brora where coal is worked, is not observable where the superior strata are in immediate contact with the granitic rock.

From Portgower to Helmsdale, the coast hills are again covered with diluvium, concealing at that place the strata on both banks of the river; but the shelly limestone is extended into ledges on the north bank of the harbour, and the worn surfaces of some of these beds expose a mass of flustræ, mingled with univalves and spines of echini.

Navidale.

The granitic mountains retire gradually from Helmsdale, and again advance to the coast at the Ord of Caithness, thus inclosing this little valley. The solitary House of Navidale is placed upon a green knoll, flanked by narrow glens, and overlooking a small pier. The base of the cliff is composed of the shelly limestone, which very much resembles certain beds of the oolite near Bath. Above the limestone, and immediately below the House of Navidale, the sandstone is in contact with the granitic rock, the latter in various stages of decomposition, and the former highly inclined. In proceeding to the N. E., the place of the shelly limestone on the shore is occupied by a conglomerate much more coarse than that near Portgower, and apparently derived from all the strata which have been described as occurring from Kintradwell to Navidale; viz. micaceous shales, calciferous grits, and indurated limestone and sandstone. The admixture of finely comminuted shells disappears, but an occasional ostrea, or other fossil of firm texture, is still included between the fragments, which are united by a sandy calcareous cement; the whole mass bearing much the appearance of an old and weathered wall.

The indurated shales of this conglomerate might, in hand specimens, be mistaken for grauwacke: but, upon a careful inspection of the whole coast, and, after observing the change of character which occurs in the beds at and near their contact with the granitic rock, a conviction follows, that, in proportion as the disturbing causes have become more active, a breccia has been compounded from the whole suite of the superior strata of the deposits upon this coast, and that the portions of it which resemble grauwacke are only the sandy shales of the oolitic series in an altered state.

Other geologists may be of opinion that some of these indurated shales with

an associated limestone have been derived from the slate of Caithness, which is very largely developed to the north of the Ord; but such an inference can hardly be admitted, since the latter alternates with the sandstone of the red conglomerate, elsewhere shown to be composed of those granitic and older rocks, of which latter there is not a vestige in this singular breccia.

The beds of limestone near the Ord have also an altered character. They are very compact, of a semi-crystalline structure, void of fossils, much charged with ferruginous matter, highly elevated, and traversed by veins of crystallized carbonate of lime.

Here the cliff is generally from 80 to 120 feet in height, divided by numerous ravines, in the bottoms of which the granitic rock is disclosed by the streams flowing from the mountains of the interior. Irregular conical masses, chiefly consisting of a highly ferruginized cellular sandstone, in which all traces of stratification are lost, stand up in the mouths of these narrow defiles.

These are terminated by a peninsulated terrace, called the "green table," which serves as a pedestal to the Ord of Caithness; and, at its base, the breccia rising from the sea with a rapid inclination, forms an admirable breakwater against the waves of the German Ocean, to the violence of which this promontory is fully exposed. (See Section, Pl. XXXI. fig. 2.)

It has been frequently remarked that, wherever the granitic rock appears, the beds in contact with it are elevated, and, in many instances, shattered into fragments: hence it would seem that such phænomena can only be explained by supposing the former to have been thrown up at periods subsequent to the deposition of the latter.

East Coast of Ross and Cromarty.

I could discover no portions of the oolitic series to the north of the Ord of Caithness; and, to the south of the district described, the low coasts of Sutherland and Ross are composed exclusively of the sandstone of the red conglomerate, occasionally accompanied by a lamellar sub-crystalline limestone. My attention, however, was directed by Sir George Mackenzie to certain beds with fossils which occur near those remarkable headlands the Sutors of Cromarty.

At the northern extremity of a narrow mountainous ridge which there occupies the coast, the red conglomerate rises from its horizontal position in the plain of Easter Ross*, where it is for the most part in the state of a fine-grained sandstone, and, swelling into hills which bound Shandwick Bay upon the south,

* These plains of Easter Ross are celebrated for their fertility and abundant production of wheat. This agricultural distinction is very remarkable in so northern a latitude, and affords a

is recumbent with a highly inclined dip upon a granitic rock, very similar to that of the Ord of Caithness. Near this junction, beds of dark coloured micaceous shale, only visible at low water, dip away from the coast, resting unconformably upon the edges of the sandstone of the red conglomerate. These shales extend about three quarters of a mile from N. to S., and, at low ebbs, are developed through an equal space from W. to E. They are remarkably curved in one situation, where the softer portions having been washed out, the harder shales with limestone rise one above the other, and thus present the appearance of seats in an ancient theatre.

The laminated beds contain a compact blue argillaceous limestone marked by veins of carbonate of lime; and nodules identical with the cement stones of the alum shale are not unfrequent. The fossil shells which I procured during one ebb of the tide are those of the lias; viz. gryphæa gigantea, G. incurva; ostreæ, belemnites, ammonites, &c.

These beds are cut off upon the south by lofty cliffs, the insulated and broken peaks of which continue to distinguish this bold coast on both sides of Cromarty Bay. These cliffs are composed of various primitive rocks, much elevated and contorted, traversed by numerous veins of the granitic rock. (See Pl. XXXI. fig. 3.)

Passing to the south of Cromarty Bay, the coast is still chiefly occupied by cliffs of the granitic rock; but the black shales and blue limestone beds reappear in Ethie Bay, where a fine-grained whitish variety of the red conglomerate composing that large peninsula of Ross-shire, called the "Black Isle," is elevated into lofty hills. Many of these beds at Ethie, although principally composed of granitic detritus, contain much calcareous matter: others, it must be stated, strongly resemble the old red sandstone of South Wales, particularly in having a subordinate bed of red limestone which is very similar to the cornstone; and the whole suite is interspersed with much mica, chlorite, and indistinct corbonaceous markings. The shale beds on the shore are clearly a portion of the same series as those beyond the North Sutor, from which they are distant about eight miles. They dip away from the coast at about an angle of 30°; and, with the exception of some partial dislocations and contortions, they

---

slight ground for presuming that the sandstone of these districts may be the equivalent of the newer red sandstone which is so uniformly distinguished in England and elsewhere by the richness of its soil; the sandy tracts of the old red being usually marked by their sterility. The stone of the Red Castle and Tarradale quarries strongly resembles some beds of the new red sandstone near Bristol; and sulphate of strontian, a mineral characteristic of that formation, is found at Clachnacarrich near Inverness: which place, although to the South of the Murray Firth, may still be considered within the range of the red conglomerate.

are nearly conformable to the inferior red conglomerate, although their junction with that rock is obscured by boulders and shingle. The shale here contains blue limestone nodules, much lignite and carbonaceous matter, numerous casts and impressions of ammonites, very slender belemnites (a variety of the belemnites abbreviatus of Miller), and scales of fish of a rounded form, some of which are converted into bitumen. The most remarkable bed is a calcareous aggregate of fossils, amongst which is an ammonite, (probably the A. Königi,) gryphæa incurva, a new species of plagiostoma, and an undescribed bivalve. In the more compact blue limestone are clusters of young ammonites, resembling those of Watchet in Somersetshire, and of so minute a size as scarcely to be distinguishable by the naked eye. These beds, as well as those near the North Sutor, are clearly of the lias formation, and therefore may be regarded as the base of the series described at Brora, where the inferior oolite with its subordinate coal-seams dips below the level of the sea.

The elevated coast ridge near Cromarty displays upon its eastern side not only the relation of that series to the red conglomerate, but also proves the latter to have been the only intermediate deposit between the lias and the primitive rocks.

Although in several places near Cromarty an unstratified granitic rock resembling that of the Ord is occasionally seen in contact with the red conglomerate (this latter in such cases being always highly inclined), yet the greater portion of the cliffs on the southern part of this coast consists of the stratified primitive rocks. Thus between Ethie and Rosemarkie, micaceous and hornblende schists alternate with talcose, white quartz and red felspar rocks, most of which are highly elevated and much foliated.

I examined a great part of the east coasts of Inverness, Moray, Banff, and Aberdeen, without discovering any traces of the stratified beds with fossils above described: and, if the comparison which I have instituted between them and those of the Yorkshire coast be correct, these two deposits, though apparently separated from each other by an interval of more than 250 miles, must have originated in the operation of similar causes, and are consequently referrible to the same geological epoch.

Western Islands.

Skye.

In the "Geology of the Western Highlands," vol. i. p. 339, Dr. MacCulloch, after remarking upon the secondary strata of this island, adds, "other analogies will also readily suggest themselves to English geologists," &c. I will

therefore proceed to notice those beds which came under my observation, and which further confirm the analogy between these deposits in the Highlands of Scotland and the oolitic series in England.

On the north-eastern side of the harbour of Portree, the lofty trap rocks which occupy the cliffs upon the coast, retire from the sea, and bound a small elevated vale called Beal, of about half a mile in length and 200 yards in breadth. The beds of which the higher part is composed, consist of a calcareous agglomerate of fossils, not to be distinguished from many portions of the English cornbrash and forest marble, whilst, in some parts, it resembles those fissile beds of oolite, which cap the cliffs at Bridport in Dorsetshire, overlying the sandstone of the inferior oolite. The characteristic fossils, like those of the shelly limestone on the coast of Sutherland with which it is identical, are the terebratula inconstans and the avicula inequivalvis, and the beds containing them here, as well as at Brora, are overlaid by a yellowish white sandstone. These beds present a mural escarpment to the coast dipping slightly to the N.W. in conformity with the arenaceous strata containing large nodular calcareous concretions upon which they rest. This Beal limestone is fissured to its summits by several dykes of greenstone, both compact and amygdaloidal. Most of these are empty, but one is still filled with zeolitic greenstone, having numerous small veins ramifying from it, but the regularity of dip is not in this case altered by the intruding rock.

On approaching Holm, the sandstone is seen rising to a considerable height from beneath the fossil limestone, but is obscured by the trap towards the higher parts of the cliffs, though it exhibits greater regularity of structure near their bases; containing those calcareous concretionary nodules with fossils, which elsewhere mark the lines of stratification in the sandstones of the inferior oolite. Amongst these fossils are the mya V. scripta, pectens, serpulæ, encrinites, belemnites, &c.

To the N.E. of Holm the sandstones and shales retiring from the coast, ascend into a lofty escarpment, over which the cascade of Eas-veririg falls, at a few hundred yards from the beach. Impressions of vegetables found in these sandstones belong apparently to the same family of plants which has been described in treating of Brora, and ostreæ are here also found attached to carbonized wood.

At the base of the sea cliff, beds of sandy micaceous shale contain compacted masses of the large belemnites abbreviatus, so characteristic of the inferior oolite, with limestone nodules, masses of ammonites, and some undescribed bivalves: amongst the ammonites is a new species figured in Min. Con. tab. 550.

That the strata of this series were originally continuous from the high cliffs between Portree and Holme to the low coast on the opposite side of the island, as stated by Dr. MacCulloch, I can confirm, having found several fossils in blue shale through which a deep canal has recently been cut by Lord Macdonald, to drain the lake of Mugsted. Among these shells are the ammonites Königi, ostreæ in masses, many belemnites, flattened tellinæ? &c.

The features of this island and the extraordinary relations of the secondary strata to the trap-rocks, have been so fully described in the "Geology of the Western Islands," that I abstain from any further detail, and simply refer to the tabular arrangement, (p. 321,) for a list of the fossils which I collected in various parts, viz. on the N.E. coast, at Loch Sligachan, and also in the Isles of Scalpa and Pabba. In addition to many acknowledged shells of the corn-brash, inferior oolite and lias, there are several new species: of the latter, the gryphæa which pervades the lower shale and limestone of the Hebrides, and has been named after the geologist who first described it, is particularly to be mentioned. (See Min. Con. tab. 547.)

The gryphite limestone of Broadford and that of Sconser, containing ammonites, encrinites, pinnæ, &c., are members of the lowest formation in the series, which may now safely be assigned to the lias of English geology, the superior strata having been shown to belong to the overlying oolites.

Mull,

The most southerly part of the Western Islands in which the strata of the oolitic series have been noticed, is upon the S. coast of Mull; on a part of which I examined the beds in detail. From beneath the low and insulated promontories of greenstone and amygdaloidal trap on the W. of Loch Buy, sandstone and limestone rise into lofty cliffs at Carsaig House, below which extensive beds of micaceous shale accompanied by veins of dull blue limestone are uncovered upon the shore at ebb tide. Their structure resembles exactly that of the shales of Pabba and Scalpa; and the beds in these different places contain many of the same fossils, viz. belemnites, gryphites, pectens, two or three ammonites, including, the A. Conybeari of the lias and a new species, A. Jamesoni (Min.Con. tab. 555), which, although never previously described, is found in the lias shale of Robin Hood's Bay near Whitby. The shale is overlaid by a yellowish micaceous sandstone, distinguished here, as in the Isle of Skye, by large calcareous concretionary nodules containing fossil shells; by which, and by immediate superposition to the gryphite shale, these beds are at once recognized as belonging to the inferior oolite. The best general section of the strata is seen upon the west side of the defile near Carsaig

House, where the sandstone with calcareous spheroidal nodules rests upon the shale; and the former rising high in the precipitous cliff, is overlaid and broken by trap and basalt. The structure of this sandstone is identical with that of many beds upon the Yorkshire coast, and natural caves are of frequent occurrence in it *.

Limestone containing imperfect fossils occurs in the uppermost beds, and also a lignite which has been partially worked for fuel: but I could not distinctly ascertain the order of superposition in the higher parts of the cliff; for here, as well as upon the N. E. coasts of Skye, it is in the lower part only that there is any regularity of stratification, the summits being invariably obscured by superincumbent trap.

The strata on the S. coast of Mull reach to nearly as high elevations as in Skye; but to the west of the rugged shore of the Inimore of Carsaig they are gradually brought down, and are obliterated by the basaltic rocks which form the wild and gigantic promontories of Ben Macquarrie and MacCullum's Point †.

The preceding details have shown that upon the N.E. coast of Scotland, the strata above the lias are visible only in low cliffs, or in beds exposed at ebb tides; the distance which they occupy at intervals from N. to S. being about 40 miles, and their greatest breadth from E. to W. about 3 miles.

On the N. Western coast, different members of the same series are to be traced, through a space of 120 miles, from the Shiant Isles on the N. to the S. coast of Mull, frequently swelling into cliffs of great height. They are, however, so traversed and overlaid by trap and basaltic rocks, that the precise relations of one bed to another are in many situations rendered equivocal, although the fossil remains of the whole suite are clearly referrible to various oolitic formations, which are seen to be based upon the lias.

In the Brora district, however, each bed has been distinctly assigned to its equivalent in England. The strata containing the coal have been shown to be identical with those of the Eastern Moorlands of Yorkshire, which are the

* One of the largest and most remarkable of them is called the Cave of the Nuns; and the spheroidal nodules above described project from its sides and roof. The sandstone is quarried near the cave, which is used as the abode of the workmen. Communication with this sequestered habitation can only be made by sea.

† For a picturesque sketch of this unfrequented spot, I refer the reader to the Earl of Compton's Views, illustrative of his memoir on the *trap-rocks* of this coast. (Geol. Trans. vol. v. part 2.) and for the singular changes which some of the stratified beds undergo in contact with these basaltic masses, the geologist must consult the "Western Islands" of Dr. MacCulloch.

connecting links with the oolites of the midland counties of England: and without their intervention as terms of comparison, much obscurity might still attach to the geological place of these northern deposits; for the apparent anomaly of the latter, in having lost the oviform structure or usual type of formation, is reconciled, when it is seen that in the beds of the district with which they have been compared there are few or no traces of oolite.

Red Conglomerate.

The entire absence of the carboniferous series in the N. E. of Scotland, renders it difficult to determine the age of the red conglomerate which in those districts, is *alone interposed* between the lias and the primitive rocks; since it is now admitted that the new red sandstone cannot, in some situations, be mineralogically distinguished from the old, when these two formations are not separated from each other by the carboniferous or mountain limestone, which being wanting, all inferences respecting the age of this conglomerate must be deduced from its internal characters. The different appearances which it assumes in Sutherland and in Ross-shire have already been described. Near the North Sutor of Cromarty it has been stated to be unconformable to the lias, to which it succeeds: but this fact can lead to no conclusion, because the strata there are much disturbed, the beds of lias being much contorted, and the red sandstone, which is but slightly inclined throughout the adjoining country, is in this place nearly vertical, owing to the proximity of the elevated granitic ridge. On the other hand, at Ethie Bay, where the strata are less disturbed, the beds of lias are conformable to the general range of the inferior sandstone.

Although the latter deposit in Ross-shire and in Sutherland does not, as far as my observation went, contain any substances sufficiently peculiar to mark its date, still it should be stated, that in some parts of those counties there are traces of carbonaceous matter; and the great fertility of the plains of Easter Ross (see note, p. 308) affords also some slight ground for presuming that this great deposit may be referred to the age of the newer red sandstone. More decided conclusions can, however, be drawn from certain remarkable organic remains recently observed in the bituminous schists of Caithness, which appear to be subordinate to, or contemporaneous with, the same conglomerate.

The extensive plains of Caithness forming the N. Eastern extremity of Scotland and succeeding in that direction to the E. coast of Sutherland described in this memoir, are composed of bituminous schists; in some places accompanied by beds of compact lamellar sub-crystalline limestone; in others by a close-grained calciferous and micaceous grit; whilst the promontories of

Dunnet, Thurso, &c., consist of a moderately fine-grained red sandstone overlying and alternating with schists, and a lamellar limestone in the adjoining bays*; the whole deposit seldom deviating from slight inclinations to the east or west of North.

The horizontal beds forming the rock of Dunnet Head, the most Northern point of Great Britain, are made up of an uniform mixture of quartzose sand with particles of mica, the structure distinctly stratified and the folia thin. The colour is there of a brownish red, but in other places the sandstone exhibits patches and stripes of bright red alternating with yellowish gray; these markings are in some instances parallel to the strata, but are frequently irregular, and in these particulars the specimens are almost identical with the variegated or new red sandstone. It is presumed that this deposit must be of the same age as the red conglomerate of the East coasts of Sutherland and Ross-shire, since the flooring-slate of Caithness, though of superior quality, is mineralogically the same with that which is included in the red conglomerate of Sutherland and Ross; and the associated lamellar limestone throughout the conglomerate of the three counties is identical, whilst the general inclination of the strata is nearly the same.

At Banniskirk, where the slate is extensively quarried, abundance of fossil fish have been found for many years past; but the attention of the Geological Society was led to them by M. Culley, Esq.†, who last year sent specimens from thence. I have since visited these quarries; they are about eight miles south of Thurso, and near the rise of a low range of hills, which bound upon the South the extensive plains that are spread out from thence towards the Pentland Frith.

The fish occur exclusively in a schistose bed of a few inches in thickness, about three feet below the uppermost stratum, and immediately overlying the slate which is quarried for use. The bed containing them is rejected by the workmen, and it is from the fragments scattered around the quarry that specimens are to be obtained. When first brought to light these fish are of the

* The most valuable and extensive quarries of these Caithness slates, are at Castle Hill in Dunnet Bay (the seat of Sheriff Traill). The slate of these quarries, though chiefly composed of alumine with some silex and mica, &c., contains pyrites and also a portion of lime, as most of the specimens effervesce slowly with acids. The shale which alternates with the calcareo-siliceous schists of Barrogill Bay is so highly bituminous, that it burns with a bright flame. In the sandstone quarries of Thurso a much purer black bitumen is found, generally associated with crystals of carbonate of lime.

† Mr. Culley has been for some time zealously occupied with the geology of the *primitive* and central districts of Sutherland and Caithness; and, I believe, will shortly offer to the Geological Society his observations, accompanied by sections from the East to the West coast.

same dark gray colour with the slate itself; but after exposure to atmospheric influence they generally acquire a purplish blue tinge, whilst the surrounding matrix is externally changed to a light brown.

No icthyologist has yet determined the family to which these very singular remains belong. Having forwarded specimens of two or three distinct species to Baron Cuvier, I shall not upon this occasion say more respecting them; but may here state generally, that the red sandstone of Caithness, the lamellar limestone, and the schists containing the fish, have all strong resemblances to the copper slate of Thuringia and its associates, and may probably prove to be the equivalents of that formation; whilst the fish, though not of the same species, may belong to the same family as those found at Mansfeldt.

Whatever may be our conclusions respecting this deposit, the preceding pages afford, it is hoped, a good exemplification of the value of the geological evidence to be derived from organic remains; since the existence of strata, which must be regarded as the representatives of a large portion of the *oolitic series* of England, has been clearly shown by the identification of their shells and vegetables, although at the extremes of that series in Great Britain the mineralogical character of the beds is perfectly distinct.

Concluding Remarks.

The following remarks, which are of a nature partly theoretical and partly practical, appear to flow naturally from the facts detailed in the preceding paper.

1. A constancy in the mineralogical character, and the order of superposition of the strata of any country, are undoubtedly the first facts upon which its geological structure must be determined. That the great deposits superior to the carboniferous order are capable of being divided into groups; that many of these groups range in the form of natural terraces from one side of our island to the other; that even their subordinate beds preserve through considerable portions of their range, a great uniformity of structure and of external character;—are facts now established by a great accumulation of direct evidence. It would not perhaps be too much to assert, that the physical structure of many parts of England might be determined by these characters alone, without the help of any zoological considerations. But the foundation for a true arrangement of our strata being once established, we are by no means precluded from the use of any other characters with which nature may supply us. The organic remains imbedded in the successive secondary strata are not only essential to all theoretical speculations, but enable us to determine the true place of many deposits in districts where we have not the advantage of

any good natural sections. The progress of investigation has enabled us to go still further. Certain genera and species of fossil shells have been shown to be so characteristic of deposits of a particular geological æra, that we have in many instances been enabled to fix the epoch of a formation by zoological characters alone; where (in consequence of some local causes) all other evidence has been wanting. The history of the Brora coal-field is a new instance of this kind of generalization. The several parts of this deposit have been brought into comparison with certain portions of the English oolitic series, solely by the help of zoological characters. This generalization is fully confirmed by the phænomena presented on the Yorkshire coast. We have there a repetition of the peculiarities of the Brora coal-field and some of the same fossil plants; but still under circumstances which seem to put the great relations of the deposit entirely out of doubt.

2. If the preceding remarks show the great importance of attending to the fossil history of our several formations, the facts stated in the former part of this paper at the same time prove the absolute necessity of examining the mineralogical structure and relative position of the subordinate beds, wherever they are exhibited in natural sections. It is only by a comparison of all such characters, that geological induction can be established on a firm basis. Several of the organic remains in the annexed catalogue are entirely new. It is, therefore, probable, that, in remote parts of the European basin, there may be formations of lignite of the same age with the Brora coal, in which the suite of fossil remains will be found to present very few analogies with those which distinguish the oolite of England. Every thing with which we are acquainted tends to show, that Nature in modifying the solid parts of the earth's surface has acted by very general laws. There appear to be no sudden transitions in the zoological history of the same formations during their range through different latitudes. Every new fact in their natural history becomes therefore of importance; inasmuch as it may give us a new term of comparison between our own strata and those in distant countries. And we may venture to hope, that, as minute details become multiplied, many more new terms of comparison will be discovered, which may form so many connecting links between distant contemporaneous deposits; so that we may not only generalize with more certainty in neighbouring regions, but be enabled to extend our inferences to the remotest parts of the Earth.

3. If we assume that the coal-fields at Brora and on the Yorkshire coast are contemporaneous, and also the equivalents of the several formations which intervene between the Oxford clay and the lias; we must at the same time admit, that the causes which produced the oolitic deposits in the central and

southern parts of England, must in some other regions have been modified by the simultaneous operation of certain powerful disturbing forces. One exception to the common structure of a formation would point to no general conclusion. But two exceptions of the same kind, occurring at a considerable distance from each other, and precisely on the same line of deposit, almost compel us to speculate upon the causes which have produced them, and to regard them as the result of some general law. Are there then many carboniferous deposits, subordinate, like those described in this paper, to the inferior portion of the great oolitic series? This question is of great theoretical and practical importance. In some parts of Somersetshire, beds of clay containing much carboniferous matter are associated with the forest marble. In the well-known quarries of Stonesfield there is an extraordinary development of vegetable fossils, and, at the same time, the ordinary type of formation is greatly modified. Again, in the range of the oolites through the North-western parts of France, a similar development of vegetable fossils has been discovered in beds which are immediately inferior to the Oxford clay *. If the mode of distribution and the generic characters of these fossil plants be ever reduced under general laws, they will no longer be regarded as anomalies; but will form an important addition to the natural history of the beds with which they are associated. The preceding account therefore, of the fossil vegetables of Brora and of the East Coast of Yorkshire, may help us to the conclusion at which we seem now to be on the point of arriving, by means of the labours of Mons. Adolphe Brongniart, and some other naturalists.

Whatever may have been the nature of those destructive agents which attacked the existing materials on the earth's surface, and spread them out in numerous alternations of sand, mud, and vegetable matter, thereby laying the foundation for future carboniferous deposits; it is quite certain that their operation was not confined to one particular epoch. Their greatest effects appear undoubtedly to have been produced at a time anterior to the deposition of the newer red sandstone; but the details above given, prove that they have also come into action at subsequent periods: nor can we, in the present state of our information, pretend to affix any precise limits to the extent of their operation. In all the greater carboniferous deposits, of whatever epoch, there appears however to be that similarity of mineralogical composition which implies a similar mode of formation. Hence, in the oolitic series, where these peculiarities are wanting, and where the several strata are developed in conformity with the more ordinary type of those formations, we may venture to

* Annales des Sciences Naturelles, Avril 1825.

predict with certainty, that no carboniferous deposits of any great value will ever be discovered, at all events in Great Britain. A want of such knowledge has induced many persons to make trials for coal in beds subordinate to the English oolites, and even superior to them, in places where the type of formation did not offer the least warrant for such attempts. These speculations have ended, and always must end, in disappointment and ruin.

TABLE OF FOSSIL SHELLS.

The Figures refer to "Mineral Conchology," and the new species have been named by Mr. Sowerby.

List of Species and their Localities in SCOTLAND.	*Formations and Localities in which the same Species occur in* ENGLAND.
Braambury Hill quarries or highest beds in the Brora district, consisting of rubbly limestone and siliceous sandstone.	Calcareous grit and sandstone, or base of the coral rag formation.
Chambered Univalves.	
Ammonites vertebralis. Tab. 165	In a siliceous limestone of the calcareous grit beneath the coral rag at Dry Sandford and Marcham, Oxon.—Base of the calc. grit, Sevenbeck, Eastern Moorlands of Yorkshire.
——— cordatus. Tab. 17, fig. 2 and 4 .	In the calc. grit of Shotover Hill, Oxon; Cayton Bay and Scarborough Cliff, Yorkshire.
——— perarmatus. Tab. 352	Abingdon, Oxon.; Malton and Scarborough Cliff, Yorkshire.
——— new species, not figured, resembling a nautilus.	
——— new species, with bifid ribs.	
Bivalves.	
Cardium dissimile. Tab. 553, fig. 2	Portland, Tisbury, Aylesbury, &c.—It is remarkable that this fossil, hitherto called the Venus of the Portland-stone, is found at Brora in a mass of fossils of the calcareous grit.
Cucullæa, 2 species, not determined . . .	The genus cucullæa is found in almost every formation above the lias.
Gryphæa nana. Tab. 383, fig. 3	In groups in the calcareous grit, Scarborough; also at Shotover Hill, Oxon.
——— bullata. Tab. 368	Horncastle, Lincolnshire; also at Scarborough?
Lucina crassa, new species. Tab. 557, fig. 3 .	Horncastle, Lincolnshire; Feldmarsham, Oxon; Scarborough Cliff?
Modiola bipartita. Tab. 210, fig. 3 and 4 . .	Bedford Castle; Scarborough Cliff, &c.
Pecten, large ribbed species, not vet figured .	Marcham Field, Oxon; and Scarborough Cliff.

SCOTLAND.	*ENGLAND.*
Pectens; two new species not figured, but much resembling P. of Malton. Tab. 543. fig. 1 & 2.	
Plagiostoma obliquata; new species to be figured in Min. Con.	Malton?
Large casts of a gibbose bivalve, either a Venus or Cytherea.	

Reefs at Dunrobin, &c.	
Shale and grit	Oxford clay, &c.
Chambered Univalves.	
Ammonites, (flattened impressions of) . . .	Similar ammonites in the Oxford clay.
Belemnites sulcatus. Geol. Trans. vol. ii. Pl. VIII. fig. 5.	This variety of belemnite is characteristic of the Oxford clay.
Bivalves.	
Astarte, resembling elegans	The A. elegans is found in various oolitic formations from the coral rag to the inferior oolite inclusive.
Avicula, new species, not figured	This species occurs on the Yorkshire coast.
Gryphæa nana. Tab. 383.	Oxfordshire and Scarborough.
Modiola pallida. Tab. 8.	Green sand Fonthill, Wilts.
Pecten, smooth species.	
Plagiostoma pectenoides. Tab. 114. fig. 4. . .	Pickeridge Hill.
Pullastra? not figured	The same bivalve is found in abundance near Scarborough, and in all the fossil beds above the coal on the Yorkshire coast.
Serpulæ	Oxfordshire, and the Yorkshire coast.
Terebratulæ	

Portgower, Helmsdale, and Navidale.	
Shelly limestone and calciferous grit	Cornbrash, &c.
Univalves.	
Nerita lævigata. Tab. 217.	Dundry.
Turritella muricata. Tab. 499. fig. 1 & 2. . .	Steeple Ashton, Wilts; and also on the Scarborough coast.
Many spires of univalves.	
Bivalves.	
Astarte elegans (small variety). Tab. 137. fig. 3.	In many of the oolites.
Avicula inequivalvis. Tab. 244. fig. 2 & 3. .	Cornbrash and forest marble.
Terebratula inconstans. Tab. 277. fig. 3 & 4.	Cornbrash, and also in Oxford clay.
Ostrea deltoidea? Tab. 148.	
Smooth spines of echino-cidaris	Stonesfield slate, &c.
Tooth of Saurian?	
Coralloids. Flustræ?	

SCOTLAND.	*ENGLAND.*
Small belemnites.	
Pentacrinus?	
Inverbrora coal pits, and beds overlying coal upon the shore.	
Sandstone, limestone and shale	Eastern Moorlands of Yorkshire.
Chambered Univalves.	
Ammonites Gowerianus, new species. Tab. 549. fig. 2.	
——— three new species, not figured.	
Belemnites sulcatus. Geol. Trans. 2d. Series, vol. ii. Pl. VIII. fig. 3.	Oxfordshire; also at Dundry.
Univalves.	
Buccinum, species not decided	These univalves occur in the pier stone of Scarborough above the coal.
Rostellaria composita, new species. Tab. 558.	
Corbula, new species not figured.	
Bivalves.	
Astarte elegans. Tab. 137. fig. 3.	Oolite near Bath; Babling Hill near Yeovil; in the coral rag of Steeple Ashton; Robin Hood's Bay, Yorkshire.
Avicula?	
Cardium striatulum, new species. Tab. 553. fig. 1.	
———, new species, resembling C. truncatum.	
Cucullæa, 2 undescribed species.	
Gervillia (formerly Perna) aviculoides. Tab. 66. fig. 3.	Scarborough coast in the pier stone and other beds above the coal; Osmington, Weymouth, &c.
Lucina, species not yet figured	The same species is found in Oxfordshire.
Modiola cuneata. Tab. 211. fig. 1.	Scarborough Castle Cliff; oolite near Bath.
Mya depressa. Tab. 418.	Horncastle, Osmington, Shotover Hill, &c.
—— literata. Tab. 224. fig. 1.	Scarborough coast.
Ostrea deltoidea	The same O. is in the Scarborough pier stone.
Pholadomya Murchisoni, new species. Tab. 545.	Very nearly resembling the P. of the Scarborough pier stone.
Plagiostoma obliquata, new species, same as in the sandstone of Braambury: to be figured in Min. Con.	
——— acuticosta, new species. Tab. 546.	Oxfordshire.
Pullastra? new genus	Found in *all* the beds above the coal upon the Scarborough coast.
Pecten lens. Tab. 205. fig. 2 & 3.	Oxfordshire.
——— new species ribbed, not figured.	
——— new species smooth, not figured.	
Sanguinolaria undulata, new species. Tab. 548.	
Trigonia clavellata. Tab. 87.	Abundant on the Yorkshire coast; also at Weymouth.

SCOTLAND.	*ENGLAND.*
Trigonia, new species, not yet figured, resembling T. costata.	
Tellina ?	
A gibbose, transversely undulated bivalve; genus not yet decided, but a marine shell.	
Venus, new species, orbicular, not figured.	

East Coast of Ross and Cromarty.	
Blue shale and limestone	Lias shale and limestone.
Chambered Univalves.	
Ammonites biplex. Tab. 193.	Lias ?
——— Königi. Tab. 263.	Lias; Charmouth. N.B. The A. Königi and the new species are so grouped as to resemble the *Marston stone.*
———, new species ? not figured . . .	
Belemnites elongatus. Miller. Geol. Trans. vol. ii. part 1. new series	Lias; Lyme and Whitby.
——— abbreviatus. Miller. Geol. Trans. vol. ii. part 1. new series	Inferior oolite and lias.
Bivalves.	
Gryphæa gigantea. Tab. 391.	Lias; in Gloucestershire.
——— incurva. Tab. 112. fig. 1 and 2. .	Lias; Dorsetshire and Whitby.
Plagiostoma concentrica, new species. Tab. 559. fig. 1.	Lias.
Sanguinolaria, new species, not figured.	
Other bivalves not yet described. Scales of fish of a rounded form	Lias shale at Lyme.
Clusters of very minute young ammonites . .	Watchet, Somerset; in the lias limestone.

WESTERN ISLANDS.	*ENGLAND.*
N. E. Coast of Skye.	
Shelly limestone of Beal near Portree, resembling that of Navidale, Sutherlandshire . .	Cornbrash, forest marble, &c.
Bivalves.	
Avicula inequivalvis. Tab. 244. fig. 2. . . .	In the cornbrash of Oxfordshire and Gloucestershire; also in Kelloway rock, &c.
Terebratula inconstans. Tab. 277.	In Oxford clay, cornbrash, &c.

WESTERN ISLANDS.	*ENGLAND.*
Micaceous sandstone with calcareous concretions, &c.; at Holm, Scorr, &c. near Portree .	Middle and inferior oolite, &c.
Chambered Univalves.	
Ammonites Königi, in blue clay at Mugsted. Tab. 263.	In Kelloway rock and in lias.
——— Murchisonæ, new species. Tab. 550. Holm Cliff	This species was found in the inferior oolite at Allington, near Bridport, in 1826.
Belemnites abbreviatus. Miller, Geol. Trans. vol. ii. part 1.	Dundry, Somersetshire, inferior oolite.
Bivalves.	
Mya V. scripta. Tab. 224	Somerford, Scarborough; Claydon, Oxon.
Ostreæ, species not decided.	
Terebratula tetraedra. Tab. 83.	Aynhoe, Northamptonshire, inferior oolite; also near Scarborough.
Tellina?	
Gryphææ compressed in masses and associated with tellinæ? a Venus and the A. Königi in blue clay, near Duntulm.	
Various bivalves with ammonites in nodules near Eas Veririg.	

Micaceous shale with inferior beds of argillaceous blue limestone. Isles of Skye, Scalpa, Pabba, Mull, &c.	Lias shale, limestone, &c.
Chambered Univalves.	
Ammonites Conybeari. Tab. 131. Carsaig, Mull	Lias; Lyme Regis and Bath.
——— Jamesoni, new species. Tab. 555. Mull	Lias shale, Robin Hood's Bay, Whitby.
——— brevispina, new species. Tab. 556. Pabba.	
——— acutus. Tab. 17. fig. 1	Lias?
——— new species not yet figured.	
——— two or three new species not sufficiently perfect to figure.	
Belemnites elongatus. Miller. See Geol. Trans. vol. ii. part 1	Dorsetshire and Somersetshire; lias.
Bivalves.	
Aviculæ in groups. Pabba	Resembling the A. of the lias.
Cucullæa, species not determined.	
Gryphæa incurva. Tab. 112	In all parts of the lias formation.
——— MacCullochii, new species. Tab. 547. Pabba, Broadford, Mull.	

WESTERN ISLANDS.	*ENGLAND.*
Gryphæa obliquata. Tab. 112. Scalpa . . .	Lias, Glamorganshire.
Pecten equivalvis. Tab. 136. Scalpa . . .	Gloucester, Ilminster, Yeovil (lias).
—— Cygnipes. Scalpa. (Figured in the Survey of Yorkshire Coast, by Young and Bird) .	Near Whitby.
——, new species, in Pabba and at Carsaig, Mull.	
Plagiostoma, species not determined . . .	Lias.
Pholadomya, species not determined. Pabba and Mull.	
Pinna granulata. Tab. 347. Sconser, Skye .	Somersetshire lias.
Sanguinolaria, species not decided: (in the upper beds).	
Casts of modiolæ and many other bivalves in the shale.	
Encrinites in the blue limestone of Sconser, Skye	In the lias at Lyme.

Note.—Of the two following fossils from the Braambury-Hill sandstone, Brora, the first has been named, and the second has been discovered, since the above table went to press.

Ammonites Sutherlandiæ—Described in the table p. 318. as a new species resembling a Nautilus: a cast of this Ammonite will be figured in Min. Con.

Avicula Braamburiensis in groups—A new species; but much resembling the Avicula echinata of the cornbrash, remarkable as being the only fossil in the Braambury sandstone which has preserved its shell; this will also be figured in Min. Con.

APPENDIX.

Brora Coal-Works.

Sir Robert Gordon states that in 1598, Jane Countess of Sutherland opened the first coal pit; probably near the old Salt Pans. In 1614 her son John, fifth Earl of Sutherland, re-opened the works; and the shaft is yet visible about 200 yards north of the old Salt House.

In the early part of the last century, the Earls of Sutherland continued to work the Inverbrora coal, sinking four or five new pits *, in one of which fifteen men lost their lives by the falling in of the roof: one of these shafts is said to have been 12 yards deep.

About the year 1764, the working of the coal was undertaken by Mr. John Williams, to which circumstance there is no allusion in his "Mineral Kingdom." He re-opened one of the pits above mentioned, which is reported to have been 26 yards deep, and sunk another near it. Also subsequently, two others N. E. of these; one 30, the other 20 yards in depth. In consequence of not excluding the pyrites, the coal was found unfit for domestic use, and liable to heat and ignite when exposed to the air. A cargo of it going to Portsoy took fire, and so much alarm was excited by this spontaneous combustion, that the sale of the coal was materially injured; and in 1769 Mr. Williams resigned his lease.

In 1770 a boring was made near Dunrobin, where two thin seams of coal were proved; but not deemed workable.

In 1777 the colliery and salt-works at Inverbrora were abandoned.

Since the Marquess and Marchioness of Stafford commenced their improvements, the following have been the operations.

In 1810 Mr. W. Hughes sunk a shaft on the north bank of the river to the depth of 83 yards, and found a thick seam of coal. (See Sutherlandshire Agricultural Report, page 148.)

In 1811 borings were made contiguous to the shaft now in use. No. 1. is a section of the strata cut through upon that occasion.

Subsequently the engine-pit was sunk about 780 yards distant from the old pit. No. 2. is a section of the beds in this sinking.

N.B.—About 70,000 tons of coal have been extracted from the pit now in use since the year 1814.

* See Memoir, p. 303.

Copy of a Journal kept whilst boring for Coal at the Water of Brora.

(Coal-pit now in use.)

No.	Date.	Description of the Beds.	Depth of each Bed. Ft.	In.
	1810.			
1	Oct. 23	Soft gray stone in this layer, containing ironstone balls	63	0
2	31	Soft dark gray sandstone in thin layers, and stones as above	18	6
3	Nov. 1	Dark, very soft coal metal in thin layers, with partings of yellow pyrites and water, which rises to the surface	2	0
4	15	Dark gray stone in thin layers, with soft partings	6	10
5	19	Dark hard stone with strong sulphureous smell	1	8
6	22	Soft sandy stone, rather lighter coloured than the above	9	7
7	29	Lightish coloured sandstone, containing marine petrifactions	14	10½
8		Very hard ironstone	0	5½
9	30	Hard gray clunch	2	9
10	Dec. 13	Light coloured metal stone, rather soft in boring	2	6
11	18	Lightish coloured clayish strata, soft in boring and containing a considerable portion of calcareous matter and marine petrifactions	2	9
12	20	Ditto, still darker, containing more of the white spar; sulphureous, effervesces briskly, but does not contain any slack after burning (calcareous)	4	0
13	25	Ditto, light coloured	11	10
	1811.			
14	Jan. 17	Ditto, still lighter coloured than the above	11	2
15	23	Ditto, much darker, containing white powdery matter	11	8
16	28	Dark clunch, a clayish strata	7	11
17	Feb. 6	Ditto Ditto	4	10
18	13	Very dark coal shale, rather soft in boring	2	7
19	20	Ditto Ditto	5	11
20	26	Ash-coloured metal stone (calcareous)	12	6
21	28	Very hard ironstone	0	5
22	Mar. 2	Ash-coloured clunch and bind	5	4
23	8	Dark bituminous shale, with soft partings	7	11
24		Very hard close-textured sandstone (quartzose sandstone)	0	8
25	April 1	Sandstone with blue streaks, soft in boring	12	9
26	17	Very hard blue grit limestone, mixed with freestone	2	3
27	18	Gray shivery sandstone, rather soft	0	6
28*	20	Sandstone, mixed with limestone, very hard in boring	0	7
29*	23	Ash-coloured metal stone, rather soft	2	0
30	May 14	Hard caking coal (main seam)	3	2
31	16	Black clunch, pavement of coal	2	0
32	18	Hard splent coal	1	4
33		Black burning shale, like Kannel coal	6	7
34		Very hard stone	1	2
35	29	Black shale	2	0
36		Very hard stone	0	2½
37	June 1	Soft black shale, speckled with white powdery matter	0	2
38	5	Hard black burning shale, came up in the auger in large pieces, very promising and not yet cut through	4	2
		Total depth bored . . . Feet	250	11½

* No. 28. and 29. are Fossil Beds, and form the roof of the coal.

Section of the Coal Strata at the Engine Pit, Brora Colliery, by Mr. William Hughes. 1814. Corrected by Robert Bald, Esq.

	Ft.	In.
1. Dark coloured schistose sandstone, containing ironstone balls and belemnites	64	2
2. Soft gray sandstone, with a little clay in the composition containing belemnites	23	2
3. Bituminous shale, fine in the texture, containing belemnites and fossil wood, the *bark of which is pure coal*	26	6
4. Dark argillaceous schistus, containing many belemnites, marine plants, impressions of large shells and some hard ball stones	6	6
5. Claystone, very fine in the texture, with smooth glossy partings, with a number of small and large petrified shells	18	4
6. Hard gray sandstone, containing fine streaks of coal with petrified wood in long pieces; some belemnites and marine shells	15	6
7. Ash-coloured hard and large-grained sandstone, sulphureous containing large pieces of fossil wood, hard balls, and a few belemnites; decomposes when exposed to the air	7	10
8. Very hard *unstratified* limestone, being a mass of shells, wood, belemnites, and a few streaks of bright coal, all concreted with lime cement	2	7
9. Very hard *ferruginous limestone*, with calcareous spar in the joints or partings	0	6
10. Dark argillaceous schistus, with smooth joints or partings, and some broken marine shells	32	6
11. Hard argillaceous schistus, the bottom composed of petrified shells and a few belemnites	0	6
12. An uniform mass of muscle, cockle and oyster shells, all concreted with lime cement	1	6
13. Dark argillaceous schistus, with smooth soft partings and a few shells	36	6
14. Very hard large-grained sandstone, with large shells and wood; this is the *roof of the coal*	5	0
15. Fine cubical coal, with smooth glossy backs, and transverse cutters; burns to a white ash, and has a peculiar smell	3	8
16. Bituminous shale, containing *natural oil;* burns, but does not consume	2	0
17. Slate coal with pyrites, not workable	1	4
Bored 15 fathoms in fire clay, alternating with argillaceous schistus	90	0
Total ascertained depth . . Feet	338	1

XXI.—*Notices and Extracts from the Minute-Book of the Geological Society.*

1.—*Notice respecting the Appearance of Fossil Timber on the Norfolk Coast.* *By* Richard Taylor, *Esq. F.G.S.* [Read Dec. 2nd, 1825.]

THE extraordinary high tide which visited the coast of Norfolk on the 5th of February last, swept away considerable portions of the cliffs throughout their course on the eastern side of the county, to the no small injury of the property exposed to its attacks, and, for some weeks, afforded an unusually favourable opportunity of examining the geological phænomena of this coast. The tremendous effects produced by a sea elevated many feet above the highest level recorded, and agitated by a strong gale blowing full upon the shore, were accelerated by the remarkable wetness of the soil. So completely were the high grounds along the eastern coast previously saturated by the land springs, that daily avalanches, or "shoots" as they are provincially termed, had occurred during the winter. Many of these shoots consisted of enormous masses of clay, mud and sand, from 100 to 200 feet in thickness, which overspread the beach with their debris and prevented all passage below, except at extreme low water; and formed an inaccessible barrier, in some cases several hundred yards in depth, for some miles along the shore, between Cromer and Mundesley. The most remarkable fall occurred in the preceding month; when a portion of the Lighthouse Cliff at Cromer, at the point where it exhibits an almost perpendicular face of 250 feet, suddenly disengaged itself, and was followed by a considerable rush of water from the rear of the fallen mass. The materials of this extensive avalanche now form a promontory, occupying twelve acres, projecting many yards into the sea. As might be expected, its surface presents a rugged and shattered appearance, such as can be only compared to the effects of an earthquake. It may be here observed, that the lower portion of the fallen cliff was projected further than the upper part; a circumstance only to be explained by observing that the water having passed freely through the sand of the upper half of the cliff accumulated in considerable quantities in the rear of the tenacious blue clay of the lower half, until

by its weight and pressure, added to that of the substratum, the base was forced forwards about three hundred yards from its former site.

In consequence of the extensive denudation of the cliffs, I obtained an opportunity of examining the site of a number of fossil trees, occurring in a stratum which I had previously traced several miles; and these were particularly exposed at Cromer, both on the east and west side of the town. I was also enabled minutely to observe this singular stratum of wood during the operation of excavating the foundations of a sea wall of unusual dimensions, whereby I intersected about two hundred feet in length, and removed a great number of trees and stumps.

This subterranean forest occupies, in general, a bed about four feet in thickness, composed of numerous laminæ of clay, sand, and vegetable remains; the whole mass varying much in colour and density, according to the prevalence of ferruginous or of vegetable matter. The trunks were found to stand as thickly as is usual in woods, and consistently with their proper growth. These stumps are firmly rooted in what appears the original soil on which they grew; but they are invariably broken off about a foot and a half from the base. The stems and branches lie scattered horizontally; amongst which are thin layers and cakes of decomposed leaves, but no fruits or seed-vessels were noticed. The species of timber appear to be confined chiefly to the pine tribe, with occasional specimens of elm and oak. They are all flattened by the pressure of the overlying alluvial strata.

I am not positive of the occurrence of any animal remains, except in one instance, when I disengaged from this stratum a portion of the skull of an animal of the deer tribe. The bones of elephants and other herbivorous animals are not uncommonly found near this site, and may have been washed out of the same bed.

The general level of the stratum on which are placed the stumps of trees so far as I have traced them, is a few feet above high-water mark: although it frequently inclines as much below, and is concealed by the loose sand of the beach. At Cromer it occurs beneath 60 to 100 feet of alluvial deposits. At the base of Paston Hill the bed, containing large stumps of trees, sustains the pressure of near 200 feet of sand, gravel and clay. Nearer Happisburgh, at Bacton Gap, it occurs with only 10 feet of superincumbent loam reposing upon it. The extreme points at which I have identified this interesting stratum are about 20 miles asunder; and throughout this extent it may be considered as continuous.

The geological fact which I have taken the liberty of thus noticing is probably not altogether new, yet is entitled to some consideration, as illustrative

of the former surface of this portion at least of the coast. That the stratum alluded to was the actual superficial soil, upon which grew and flourished an extensive forest of oaks and pines, and on which the deer, the elephant, and other herbivorous animals existed and died, there can be little doubt. Upon this surface, once comparatively level, have been piled irregular accumulations of alluvium, varying from 10 to 300 feet in thickness. There is no reason to doubt that the submarine forest which exists on the Norfolk coast, further northward, and which passes by the Lincolnshire coast to Yorkshire, is a continuation of the same stratum, on a somewhat lower level.

There is a striking similarity of appearance in all parts of this line. Numerous stumps of trees are perceptible at Thornham and Brancaster, standing evidently upon the original surface, whilst the trunks and branches cover the ground, in a horizontal direction. In general this wood is quite soft and decomposed, but contrary instances are not uncommon; and I have cut off fragments from the oak stumps, which though not mineralized, were so hard as almost to defy the edge of a hatchet. I cannot speak with certainty of any point in the central parts of this county where this woody stratum can be identified. Peaty valleys, with trunks of trees and stags' horns, are not unfrequent (and, among these, the Valley of Waveney is particularly to be noticed); but they probably have a different and distinct origin.

Cromer Terrace, March 31, 1825.

2.—*Description of a peculiar Species of Granite. In a Letter from Earl* Compton, *to the Rev. Professor* Buckland, *P.G.S. &c.* [Read Nov. 18th, 1825.]

My Dear Sir,

The subject of my present letter may perhaps be interesting to the Geological Society, and if you think so, I shall be obliged to you to communicate it to them; it will at least show, that though at a distance, they have not passed from my memory.—I have been employed for the last month in an excavation at Tivoli, in a spot where the villa of Manlius Vopiscus, described by the poet Statius, is supposed to have stood. This point is, however, disputed; and I cannot say that my excavation has produced any decisive evidence to prove its truth, though there appears to me to be increased reason to believe it. I will not however say any thing more upon that head, as I hope next spring to renew my research; but I will hasten at once to the principal object of this communication.—In the course of our excavating, we found a considerable

number of fragments of a rock, which is, as far as I can learn, entirely new, among those employed by the ancients. I have inquired of several of the principal lapidaries of Rome, and they all say that they never saw or heard of it before, as found among ancient ruins. This rock is green granite; that is to say, granite, the felspar of which is of a green colour, and exactly resembling that which is commonly called Amazonian stone. The fragments which I have found have been generally small, and some very small; the largest is about the size of a small melon. I have consulted the only two mineralogical works which I have with me, "Allan's Synonymes," and "Jameson's System of Mineralogy." In the former, Siberia is the only locality mentioned for green felspar. Jameson (2nd edition, vol. i. pages 375, 376.) states that it is found in a vein in granite, in the government of Ubinsky, in the Uralian mountains; also in contemporaneous masses in the granite of Onega; and further, that it is found in small rolled pieces on the banks of the river of Amazons. It would be interesting to know from whence the ancients derived it; as its two Siberian localities must have been little more accessible than that in the undiscovered continent of America. In endeavouring to ascertain this point, we are not entirely without a glimmering of light, as on some of these fragments, which show their original surface, there are Egyptian hieroglyphics. This circumstance induces me to suppose that green granite must have been found, though as a very rare substance, in Egypt. What these masses were, when the villa of Vopiscus was standing, it is useless to inquire; and perhaps future excavations may settle that point. By the largest mass which I had the good fortune to find, it appears that quartz was the principal constituent of the green granite; the felspar was however pretty abundant, and the mica disseminated in very small proportions, and of a black colour. In one fragment are some appearances of black acicular crystals in the quartz, probably either hornblende, or tourmaline.

Accompanying this letter, I send five specimens;—one, of which I have had a surface polished, will you be so kind as to give in my name to the Geological Society?.....I also send for the Geological Society a small specimen of a decomposing red slaty mineral, which I found in my excavation, and with which I am unacquainted. It appears to have formed part of a cornice.

Believe me, my dear Sir,

Yours very truly,

COMPTON.

Rome, May 20th, 1825.

3.—*Translation of a Letter from* Mons. de Gimbernat, *of Geneva, to* G. B. Greenough, *Esq. V.P.G.S. &c.* [Read April 7th, 1826.]

Sir,

The sulphate of soda which I have the honour to send to you, and which I request you to present to the Geological Society of London, was discovered in the gypsum which is worked by means of two galleries at a quarter of a league from Muhligen, on the left bank of the Reuss in the Canton of Argovie. I found this crystallized amorphous salt most abundantly in the northern gallery. Having observed saline efflorescences in a mass of gypsum near a mill where that substance is reduced to powder, I had the curiosity to examine the quarry from whence it was extracted, and I there saw by lamp light, that the recent fractures were studded with sparkling layers, as in mines of rock salt. I perceived by the taste that these crystals were sulphate of soda, and that the white powder spread over the walls of the gallery was the same salt which had effloresced, losing its water of crystallization by contact with the atmosphere. The length of the gallery is about 320 feet, breadth 6, and average height about 13 feet. From its entrance on the banks of the Reuss to the present works, several beds of compact gypsum were traversed; these beds were granular, shelly, of a grayish white colour, and void of salt. In the beginning of this year some saline beds were cut through, which were below those above mentioned: but the country people, who work this gypsum on their own account, paid no attention to the discovery; so that the existence of native sulphate of soda in Argovie was unknown at Aarau in May 1825; when I sent specimens of it to the Society of Natural Sciences of the Canton, with a notice upon the position of the salt, and containing hints as to the mode of working it advantageously. However, as a manufacture of sulphate of soda by the decomposition of sea-salt had just been established at Aarau, little importance was attached to this discovery, nor to the instructions for quarrying the salt, the advantages of which will be probably lost, owing to the bad management of the present works, which are conducted on principles contrary to all the rules of mining.

There are three beds of secondary gypsum *interspersed* with crystallized sulphate of soda, and separated by a thin deposit of foliaceous marl containing the same salt, but in less quantity than the gypsum. The 1st or upper bed is three feet thick, the 2nd five feet, and the 3rd (which is little cut into) presents a section of two feet. Thus this saliferous formation is at least *ten feet thick*; the depth is unknown, the beds being nearly vertical.

In stating that the salt is there *disseminated*, it must be understood that it

is not found in ridges (*en sillons*), nor in beds alternating with the gypsum, but that it is of contemporaneous formation with that rock. It is found in crystalline laminæ of several lines of thickness (and not in grains nor in regular crystals), filling up the fissures of the gypsum, and also the interior of that rock without regularity. It appears, nevertheless, that the sulphate of soda is disseminated in a direction parallel to the stratification of the gypsum; for the fracture of the rock in that direction exposes more of the salt than a transverse fracture.

The co-existence of sulphate of lime and sulphate of soda in the same rock, is as remarkable as the binary union of sulphuric acid with those bases in the *glauberite*, which is composed of those two sulphates in nearly equal proportions and in intimate union. In the gypsum of Muhligen, on the contrary, this double combination takes place separately, the two sulphates being associated, but without chemical mixture,—since there is not an atom of lime in the sulphate of soda, nor an atom of that alkali in the sulphate of lime. They are so separated, although forming an integrant part of the same rock, that it is easy to detach crystals of sulphate of soda from the gypsum, to which their adherence is very feeble;—a surprising circumstance, if we consider them to have been dissolved together and to have received solidity at the same time. It is difficult to conceive how the integrant molecules of the sulphates of lime and soda have not been intimately united in this rock, as in the glauberite,—a difference which perhaps depends upon the proportions.

This sulphate of soda is not, however, without mixture; for it contains a little iron and hydrochlorate of soda, which is attested by the bluish tint produced by the hydrocyanite of potash, and the flocculent heavy precipitate formed by the nitrate of silver.

Mr. Frey of Aarau, a skilful chemist to whom I sent a pound of the salt, analysed it by order of the cantonal society of Argovie. He has not merely proved the presence of the two salts, but he has determined their proportions per cent as follows:—

Sulphate of soda (dry)	44·4425
Hydrochlorate of soda	55·4571
Water of crystallization	0·1004
	100·0000

Iron,—an indeterminable trace.

The quantity of this salt contained in the gypsum cannot be determined, because it is strewed over the beds very unequally. The experiments which I have made have given me different proportions, from $4\frac{1}{2}$ to 10 per cent.

The property which sulphate of soda possesses, of losing its water of crystal-

lization upon contact with air, makes it impossible to preserve specimens of the gypsum with crystals of that salt, as the latter effloresces and conveys (*par épigynie*) the incorrect idea of a saline formation. I only succeeded in preserving them from falling into powder, by inclosing them, at the moment of their removal from the gypsum, in tubes or glass phials well corked.

The range of this saliferous formation makes a portion of the southern face of the Jura. It is stratified in beds extending from N.W. to S.E. in an oblique position, at angles varying to 90° rising towards the N.E. The dip of the saliferous gypsum is from 70° to 80°. This formation is the eighth in the series of rocks composing the southern slope of the Jura, beginning with the shelly conchoidal limestone (*calcaire conchoide coquille*) which constitutes the exterior envelope.

The geognostic description of the Jura not being the object of this notice, I confine my observations to those rocks between which the gypsum and the crystallized sulphate of soda are placed. Their position is between beds of the same quality of gypsum nearly vertical, and containing no salt, and which overlie other beds of secondary limestone. This last is granular, shelly, cavernous, and without fossils; its stratification is conformable. Above the gypsum is the formation of black aluminous foliaceous marl charged with sulphuret of iron, and having several beds of marly and shelly carbonate of lime alternating.

Mineralogical writers make no mention of sulphate of soda, because that salt has never been found crystallized and in abundance in rocks of any known mountains, (*montagnes bien connués,*) although it has been met with sometimes mixed with hydrochlorate of soda, and most frequently in volcanoes*.

The discovery of its existence in the gypsum of Muhlingen is interesting in a geological point of view, and because it renders henceforward superfluous the hypothesis of Klaproth explanatory of the origin of that salt in mineral waters. That celebrated chemist attributed its presence to the decomposition of hydrochlorate of soda by sulphuric acid disengaged in the bowels of the earth from sulphuret of iron or from the combustion of sulphur. This supposition, although purely imaginary, has been so received, that the scientific Berzelius repeats it in his interesting observations upon the waters of Carlsbad. It is possible that it may some day be confirmed by observation,—without which there is no science; for truth consists in facts, and not in opinions. However, as we now know that crystallized sulphate of soda exists in the heart

* Haüy has described the muriate, the borate, and the carbonate of soda, and has not mentioned the sulphate. Leonhard only speaks of the *efflorescences of this salt.*

of the Jura, it is more reasonable to infer that the waters which are charged with that salt, have acquired it in their passage through rocks of the formation of Muhlingen, or others analogous to them.

The probability in favour of this idea approaches to demonstration, from the fact, that the above saliferous formation is the same as that from which flow the thermal waters of Baden and Schinznach, both abounding in the sulphates of soda and lime. Those springs are about a league distant from Muhlingen, the former to the east, the latter to the west, of that place.

A simple and natural explanation of the origin of sulphate of soda in mineral springs is the result of the new discovery which is the subject of this notice; affording also an additional example in favour of the philosophical precept of Bacon:—"Non fingendum, aut excogitandum, sed inveniendum quid Natura ferat aut fiat."

CHARLES DE GIMBERNAT.

Geneva, September 29th, 1825.

4.—*Extract of a Letter from* B. de Basterot, *Esq. to Dr.* Fitton, *V.P.G.S.*

[Read Dec. 1, 1826.]

THE attention of geologists having been recently directed in a peculiar manner towards the beds below the chalk, I was glad to have it in my power to examine the strata in the vicinity of Folkstone, about which I had understood there still existed some uncertainty; and I devoted to that purpose a portion of the time, during which I was detained at Dover, at the close of the year 1824.

The beds of white chalk which form the cliffs for some distance on the shore between Dover and Folkstone have been so well described by Mr. Phillips, that I observed there nothing which it is necessary to mention. The gray chalk rises gradually from beneath the white in approaching Folkstone, and the two beds are very closely connected together; but a sort of natural separation is intimated by a copious spring which issues from the cliff about the place of junction. Towards the West of this place the real escarpment retires from the shore, and the cliffs are formed solely by subsided masses of white and gray chalk, the disposition of which sufficiently indicates the presence of an argillaceous stratum beneath, although the latter is no where visible either on the shore above the sea, or among the ruins at the foot of the real escarpment. About a mile from the town of Folkstone I observed for the first time, traces of green-sand among the subsided ruins, in

the form of irregular veins and masses, in a sort of chalk marl of a dirty white colour, which includes nodules of a harder substance than the rest, and contains a great number of shells, among which a species of plagiostoma was the most abundant. Immediately after this, the Folkstone blue marl (*gault*) appears in a low bank along the shore, at the extremity of a valley, which here opens towards the sea; the valley itself being formed on one side by the chalk hills, which rise to the height of nearly 600 feet, and on the other by a range of low hillocks of marl and sandstone, beyond which stands the town of Folkstone.

The real position of the strata at this place is much concealed by the subsidence of the various argillaceous beds of chalk and marl; but after crossing the under-cliff in various directions, I was enabled to trace the following succession :—

1st. White chalk.

2nd. Gray chalk.

3rd. *a*) Sand containing green particles, and indistinct organic remains.

b) Marl of a dirty white colour, much mixed with the preceding sand. This bed contains nodules of a more compact texture, and abounds with fossils, though from the soft nature of the marl, their characters are not determinable;—and it is from hence that the subsided masses already mentioned have come.

4th. The blue marl of Folkstone (*gault*), containing petrifactions in great variety. The hamites, inoceramus, a particular species of ammonite, and, above all, a small belemnite are characteristic of this bed.

5th. In fine, thick beds of sand and sandstone full of green particles, and of very coarse texture. I perceived no organic remains in this bed, but could not search for them minutely.

What I have mentioned sufficiently shows, that the Folkstone clay (or *gault*) is separated from the marly beds of chalk by a stratum of sand and argillaceous marl, abounding in green particles; and is on the other hand itself succeeded, in descending, by the sand and stone also abounding in green particles, which occupy the shore at Folkstone.

XXII.—*On the Volcanic District of Naples.*

By G. POULETT SCROPE, Esq., F.G.S. F.R.S. &c.

[Read March 2nd, 1827.]

THE volcanic formations of the vicinity of Naples, being for the most part easily accessible from that much-frequented capital, have been described in considerable detail by many geologists, particularly in the works of Menard de la Groye, Necker de Saussure, Brieslak, and the lately published volume of Dr. Daubeny. I intend therefore in the following memoir, to avoid as much as possible the repetition of facts already made public through these well-known channels, and to confine myself to such observations as I do not remember to have seen in print, and such general views of the subject as our continually increasing knowledge of the mode of production of similar formations may appear to warrant.

I consider the volcanic district of Naples to include not only Somma, Vesuvius, the coast of Sorrento, and the immediate environs of Naples, Pozzuoli, and Cuma; but also the islands of Procida and Ischia, with which they are as closely connected in composition as in geographical situation. This linear group, which ranges N.E.—S.W., is terminated at either extremity by the two principal volcanic mountains of Ischia and Vesuvius. The latter, as I have mentioned in a previous memoir, seems to be in communication with the group of Albano and Rome, through the intervention of the Rocca Monfina and other minor vents of volcanic matter scattered along that remarkable longitudinal valley which divides the limestone range of the Sabine hills from the principal trunk of the Apennines. Another chain of volcanic products seems to take off also from Ischia towards the Ponza group, through the islands of Ventotiene and San Stefano, maintaining a parallel direction with that first mentioned, and indeed with the general range of the escarpment of the elevated Apennine strata, at the foot of which these explosions have found an issue.

It is certainly a remarkable confirmation of the opinion elsewhere expressed, as to the general parallelism of lines of volcanic eruption to the nearest linear

ranges of elevated strata, that not only is there along the western coast of Italy this correspondence between two decided trains of volcanic vents, and the two parallel ranges of the Sabine mountains and the Apennines; but also, where a massive embranchment breaks off from the latter at nearly a right angle, forming the promontory which bounds the bay of Naples to the S.E. and the almost continuous island of Capri, a corresponding line of volcanic vents (viz. that connecting Vesuvius with Ischia,) is found to take off from the principal line, at no great distance, and at the same angle, so as consequently to run parallel with the transverse elevated range.

If we call to mind the general tendency of the rocks composing the secondary strata to yield to any disruptive force along fracture-lines at right angles, or nearly so, one to another, it will appear highly credible that this parallelism in two directions of the ranges of elevation and eruption, has been influenced, here as elsewhere, by that general, though at first sight insignificant, cause.

Within the space above limited, the volcanic force has at times developed itself in single eruptions, from a considerable number of irregularly scattered points; but has shown a decided preference to two principal and habitual vents, Vesuvius or Somma, and Ischia. These by the accumulated products of repeated eruptions have swelled into bulky excrescences, which exhibit, though with some difference, the characteristic features of ordinary volcanic mountains. Of the two, Ischia has been decidedly the most prolific source of erupted matter; since that portion of it which is seen above the water-level surpasses Somma considerably in bulk, and a great part of its mass must be supposed hidden by the sea. These two mountains also differ materially in figure and constitution. This is chiefly attributable to the different mineral character of the lavas which each has emitted.

Somma is an exceedingly regular volcanic mountain, though on a small scale; its lavas, (at least all that are disclosed to view) are of leucitic basalt; and although its conglomerates are not entirely basaltic, some containing a large proportion of pumice and feldspathose lava-blocks, yet these are unaccompanied by any masses of trachyte *in situ*, and may be supposed to be the scattered fragments of some of the inferior beds belonging to an earlier eruptive æra, at which the volcano may have been productive of trachyte, and broken up by some of the later paroxysmal explosions.

However this may be, all the visible lavas and the greater part of the conglomerates of Somma are basaltic; and owing to the great *fluidity* of lavas of this mineral character, they have, when protruded from the common vent, taken their course in spreading sheets down the outer slope of the mountain; while the scoriæ and fragmentary matters, projected at the same time into the

air, were spread pretty evenly over them: so that the result of successive eruptions of this kind has been the formation of a very regularly conical mountain, with a gradually diminishing slope on all sides, from the central heights to the plain around; exhibiting in the ravines that furrow its sides, as well as in the abrupt sections afforded by the walls of the great crater, its composition of repeatedly alternating beds of basalt and basaltic conglomerates, more or less irregular in thickness, but dipping uniformly on all sides away from the vent, with an inclination corresponding exactly to the external slopes of the mountain.

The eruptions of Somma seem very rarely to have taken place from any other than the central vent. The small cone on which the Camaldoli della Torre is built, and those still smaller ones immediately above Torre del Greco, which were thrown up by the eruption of 1794, are the only indications of explosions having burst forth from the side of the mountain. The vast number of vertical basaltic dykes which intersect the horizontal beds observable in the broken cliffs of the old crater (Atrio del Cavallo) bear witness, however, that the lava was not so frequently elevated to the summit of the mountain without occasioning numberless cracks and rents in its inmost structure; which, though occupied immediately by the liquid lava, seem never but in the instances above-mentioned, to have opened so far as to allow the *explosions* to find their way out at the side of the cone. There is great reason to conclude that the old crater of Somma, whose steep walls now half encircle the cone of Vesuvius, was formed by the celebrated paroxysm of the year 79, which occasioned the death of the elder Pliny. The enormous quantity of fragmentary matter projected into the air by the explosions of that eruption, which not only buried Herculaneum, Pompeii, and Stabiæ, under a bed from thirty to one hundred feet in thickness, but seems to have covered Naples itself to a depth of about ten feet, (as appears in the excavations behind the Studii Reali*,) and filled the atmosphere to such a degree as to produce complete darkness, according to Pliny the younger, for nearly three days, must have left a proportinate cavity in the mountain. The very analogous, though minor explosions of 1822, which completely gutted the cone of Vesuvius, leaving a crater *a mile in diameter,* and at least *eight hundred feet in depth,* did not eject a sufficient body of ashes and fragments to cover the base of the mountain to more than the average depth of a foot; nor at Naples, though the

* In this spot, above some made ground containing both Greek and Roman tombs, there is seen a deep deposit of lapillo, exactly similar to that under which Pompeii is buried, and which, from the way in which its strata lie, appears to have been formed at one epoch, most probably that of the eruption of Titus. See Pl. XXXIV. fig. 1.

wind mostly set that way during the twenty days continuance of the eruption, did they fall to the depth of a quarter of an inch. The crater produced by the eruption of 79 ought then to have been greater than that of 1822 in the proportion of the greater mass of projected fragments; and the apparent size of the crater of Somma, which measures about three miles in diameter, is certainly rather within than beyond what would be anticipated from this consideration.

In this view then, previous to the eruption of 79, Somma, or rather Vesuvius, (for it had then but one appellation,) was a regularly conical mountain with perhaps a flattish or but slightly depressed surface at the top; and the scanty notices we have received of its figure from Strabo and other writers of that period, correspond with this supposition. The eruptions that occurred after this epoch must have thrown up a parasitic cone in the centre of the great crater; and if we suppose the walls that circumscribed this cavity to have been considerably lower towards the sea than on the opposite side, it is obvious that in course of time the lava produced by the central cone, must have filled up the crater so far as to pour over its edge, and thence descend towards the sea. That portion of the circumference of the ancient crater which was in this manner over-flooded and concealed from view, is yet marked out most clearly by a terrace-like projection called the Pedamentina, which encircles the base of the recent cone of Vesuvius on the south side, and exactly continues the circular sweep of the remaining walls of the crater which still exist on the north; the axis of the present cone being precisely the centre of this circle. There is nothing incredible in the idea of the entire massive cone of Vesuvius having been formed since the year 79. We are acquainted with the dates of above fifty very considerable eruptions since that epoch; and less than the fourth of that number, were they as productive of volcanic matter as the eruption which broke out from the flank of Ætna, and overwhelmed Catania with its lava in 1669, would have sufficed to build up the actual cone of Vesuvius*.

I have dwelt the longer on these facts in the history of Somma, as attested by its structure, because I observe that the mode of creation of this very simple volcanic mountain, which indeed may be taken as a type of such formations, is not yet generally well understood; and that writers of high authority still continue to speak,—sometimes, of its craters being owing to the falling-in of the sides of the mountain, instead of to their being blown into the air through the violence of its explosions;—sometimes, of the whole mountain

* That the cone of Vesuvius was formed since the year 79 A.D., was the opinion of Brieslak, who, I believe, was the first to announce it. See his *Voyages dans la Campanie*, vol. i. p. 133.

having been produced by the elevation of flat strata on their edges round a central aperture, by force of elastic gases. Von Buch is the inventor of this last idea, which Dr. Daubeny and some other authors, I believe Humboldt amongst them, support.

Now the cone of Vesuvius we *know* to have been created, not in this imagined manner, but by the repeated superposition of one volcanic bed on another, all flowing from a central source; a process which cannot fail to produce this peculiar form of hill, (as is shown in the mud cones of air-volcanoes, which no one ever thought of attributing to the heaving up of solid strata of clay upon their edges). Again: the crater of Vesuvius, excavated from the entrails of the volcano by the eruption of 1822, shows the internal structure and constitution of this cone to be exactly similar to that of Somma, as seen in the Atrio del Cavallo. Their external figure and other features are also perfectly alike, allowing for the difference in size and age; and it would be therefore irrational to invent for the cone of Somma an unexampled mode of production, entirely different from that by which the same volcano has created, as it were before our eyes, the analogous cone of Vesuvius. The argument, if conceded with respect to Somma, will extend of course to the other *regularly conical* volcanic mountains in the Canaries or elsewhere, to which this process of formation from elevated strata has been attributed,—the *Erhebung's cratere* of Von Buch.

At the same time it is not to be doubted that the continual and often violent earthquake shocks which accompany the eruptions of every habitual volcano, are connected, or rather are occasioned by, elevatory expansions of the solid beds forming the frame-work of the mountain, through the disruptive force of the lava injected from below. The clefts broken in this way across the sides of the cone are no doubt the origin of many of those deep fissure-like gorges (*barancos*) which furrow the slopes of Ætna, Teneriffe, and other volcanic mountains of a large size. All I contend for is, that the parallel and sloping beds, which, with a quâquâ-versal dip compose every such mountain, were not deposited horizontally, or otherwise than at a high angle of inclination; and that the angular elevation they have since sustained, is in general comparatively trifling:—in short, that the conoidal form preserved by an habitual volcanic mountain in every stage of its formation, is owing to the same obvious cause which communicates the similar figure to a simple volcanic hillock, the produce of a single eruption,—viz. the accumulation of erupted matters round a central orifice.

To return to Ischia.—Unlike that of Vesuvius, though at so short a distance from it, this volcanic vent has produced not a single leucite, and none but

feldspathose lavas, trachytes, or graystone lavas approaching to trachyte. These (probably owing to their very inferior fluidity compared with the basaltic lavas*,) seem rarely to have flowed in thin sheets or narrow streams down the slopes of the parent mountain, but have usually taken the form of bulky excrescences, projecting like promontories from its flanks or summit; and they have moreover often burst out from lateral openings at no great height from its base, throwing up parasitic cones, consisting of fragmentary trachyte, pitchstone, spongiform scoriæ and pumice, and usually containing an internal basin. The mountain has thus assumed a deformed and irregular figure†, though still preserving a general tendency to the conoidal; and this irregularity has been no doubt much increased by the convulsive elevatory shocks which seem to have rent and displaced its component beds on many points, as well as by the vast degradation which the tufas making up the greater part of its bulk have suffered from atmospheric and aqueous erosion.

Of these tufas, some are loose and incoherent, others indurated, apparently by intimate mixture with water at the time of their deposition, in the manner of the *trass* of the Rhine volcanoes. The indurated have of course resisted the agents of destruction far more effectually than the incoherent; and these therefore, together with the solid lava-rocks, form the most prominent masses of the visible framework of the mountain. The tufa of Ischia has a very prevalent tinge of green, occasioned apparently by the intermixture of chloritic particles, or of augite under some casual modification. The trachytic lavas of the island vary much in mineral character. The generality are dark coloured, hard, and crystalline, resembling the rock of the Solfatara. Some are remarkable for very large agglomerations of glassy feldspar crystals; others for their zoned, ribboned, and brecciated appearance, enveloping rounded as well as angular fragments of very different varieties of trachyte, melting into their matrix; which cannot but recall the similar nodules that occur in the porphyries of the old red-sandstone, and in some granites. The trachytic hummock called Monte Tabor, which has been protruded from the foot of a large cone composed of pumice and ashes, called Montagnone, is, in part, of this variegated

* The universality of the fact, that under similar circumstances of slopes, &c., the feldspathose lavas have possessed a very inferior degree of fluidity to the ferruginous, or basaltic, has been fully shown in another publication (Considerations on Volcanos, pp. 90-95), and attributed to the inferior specific gravity of the component crystalline particles; which when the comminution of these particles, and consequently the liquidity of the mass, was the same, must solely determine the degree of *its fluidity, or the tendency of the liquid to move in any or all directions in obedience to the force of gravity.*

† See Pl. XXXIV. fig. 5.

nature. Elsewhere it passes into compact and slaty clinkstone; and thence again into a very large-grained and saccharine trachyte, of a dead-leaf colour, composed of glassy felspar. It rests on an outcropping bed of tertiary clay, full of shells, (of the subapennine formation,) which is extracted for making pottery, from excavations opened under the trachyte*.

The Lava del Arso, produced by the eruption of 1302, has been fully described by preceding writers. The point from which it issued in the side of the mountain is marked by a very small crater surrounded by a circular ridge composed of loose black and red scoriæ, containing numerous felspar crystals, spongy, light, and approaching (as do all the scoriæ of the graystone lavas) to pumice. Near the summit of the Monte Epomeo, the highest eminence of this conoidal island, are distinct traces of two very large craters. That facing the south seems to have been of very large dimensions, and the principal vent of the explosions of the volcano.

Vesuvius and Ischia stand at the two extremities of the district I have undertaken to describe. The interval between them presents a considerable number of ridgy and more or less insulated hills, of very inferior size and height, rising from the sea-shore, or from the general level of the plain of the Terra di Lavoro. They are composed, without exception, of trachytic conglomerate (or tufa), of which the greater part is consolidated into a rock resembling *trass*; and, though exceedingly light and porous, of sufficient coherence to be in general use at Naples as building-stone. This rock is stratified, or rather, like most alluvial conglomerates, zoned by alternating layers of different-sized fragments. Above it, is generally seen a series of similar and conformable layers of incoherent tufa or lapillo; of which also the flat ground between and around the hills consists to the extreme depth disclosed by ravines or other excavations.

Many of these hills have the ordinary figure of simple volcanic cones, with a central depression or crater. Such are the Monte Barbaro, the Solfatara, Astroni, Capomazza, the hills surrounding the Lago d'Averno, the Monte Nuovo, the western point of Procida, the Capo di Miseno, and the little island of Nisida. Others have the form of steep and narrow ridges, only partially embracing the hollows which appear to have been their craters; whilst some

* In the autumn of the last year, 1827, and since this paper was read, an earthquake has destroyed the village of Casamicciola, which is built in part over these excavations; and indeed some accounts attribute the catastrophe solely to the falling in of the ill-supported roofs of these clay-pits, but it was probably a slight local earthquake that occasioned their subsidence. Vesuvius having been wholly quiescent since its ebullition in 1822, it would be nothing surprising if the eruptive force of this volcanic focus were to find a new vent for a time in Ischia.

ridges run lengthways to a considerable distance in nearly a straight line, and offer few external indications of their volcanic nature.

The uniform internal structure and composition, however, of these hills, which is here and there observable in ravines, quarries, or abrupt cliffs undermined by the breach of the sea, proves them all to have been produced by the same process; namely, the accumulation of fragmentary trachyte and pumice projected from one or more volcanic apertures. Their component strata are invariably mantle-shaped, *i. e.* dip both ways from the axis of the ridge, a characteristic feature of all volcanic cones, dependent on their peculiar mode of formation, and which may be employed as a very useful and accurate guide towards fixing the localities of extinct vents of eruption. The northern escarpment of the Capo di Miseno exhibits this structure very satisfactorily, as likewise does the sea-ward bluff of the isle of Nisida, and the segment of a crater in the bay of Baiæ near the village of Bacoli.

The only one of these hills of which the date is known is the Monte Nuovo, thrown up in the year 1538; and this differs in no material points from the others, except that its constituent fragments have rather less of felspar in their mineral composition. Its scoriæ are indeed mostly filamentous, passing into pumice, but heavier and of a darker colour than the ordinary type of this mineral; and the fragments of solid lava, of which a very large quantity is scattered over the outer slopes of the hill, approach to clinkstone in appearance, are schistose, and often (which is remarkable,) veined with laminæ of pitchstone. Indeed many pieces are met with that contain passages from an earthy clinkstone to pitchstone, and thence into pumice. In these specimens it appears evident that the clinkstone has been partially changed by fusion into pitchstone, and this by the sudden development of aëriform fluids into pumice. These different modifications of the same substance alternate with one another in repeated zones within the same block, and are such as would probably be produced by exposing to artificial heat a mass of this rock, in which some laminæ might be, from their peculiar mineral character or fineness of grain, inclined to enter into fusion more readily than others. The more or less rapid cooling of the substance has, *here, at least,* had no effect in modifying its texture.

Next to the Monte Nuovo, the cone which may be judged to have been most recently produced is that of the Solfatara, whose well known phænomena attest that a mass of lava still exists beneath it at an intense temperature, sending forth through superficial fissures torrents of aqueous vapour impregnated with sulphuretted hydrogen. This gas, on coming in contact with the atmosphere, combines with its oxygen into sulphuric acid, which produces a series

of remarkable alterations in both the tufa and compact trachyte on which it is deposited: the former, from the greater facility with which it is penetrated by the acid, being affected to a great depth; the latter only superficially. Sulphates of alumine, iron, lime, magnesia, and soda, result from the decomposition of these rocks by the sulphuric acid; and their silex left nearly pure, in the form of a white earthy powder, is carried down by the rains, and deposited in thin beds in the lower levels of the crater. The very porous nature of these beds no doubt occasions the loud reverberation produced when they are struck sharply, which is vulgarly attributed to the existence of a vast vaulted cavity beneath. They consist of a very fine white clay, indurated by heat, and penetrated by numerous vesicular cavities, occasioned by the generation of some gaseous fluid during its consolidation: in all probability by the rarefaction of the air or water it contained, while exposed in the soft state of mud to the influence of the heat transmitted from the volcanic focus below. This hardened clay is divided into the finest laminæ, much thinner than paper, has the appearance of tripoli, and might probably be applied to the same uses.

I have in another place* dwelt sufficiently at length on the futility of supposing any cavity, vaulted or not, to exist under a volcano. The very circumstance of the violent protrusion of solid and liquid matters, which constitute the characteristic phænomena of an eruption, sufficiently proves that, so far from there being at that time any empty space beneath it, there is too little room for the mass of heated matter already confined there in a state of enormous tension by the weight and tenacity of the overlying rocks, and which in consequence at length uplifts or bursts through them with a sudden and violent intumescence. After every eruption, the residuum of ebullient lava left in the volcanic focus, having been by the generation of vapour throughout its substance cooled down below the temperature of the surrounding mass, begins immediately to receive rather than to part with caloric, and consequently to augment not to diminish its tension. No cavity can therefore be formed during this time.

The Solfatara has produced a massive current of trachyte, which stretches with a gradual slope in the form of a rocky promontory, into the sea. The upper extremity (called Monte Olibano) impends over the crater of the Solfatara in a precipitous cliff. It is hardly necessary to say that the crater must of course have been hollowed out by aëriform explosions subsequently to the flowing of this lava, which is a decided trachyte, but varies extremely in grain, texture, and even in mineral character. The upper part of the current contains much less augite than the lower, and its felspar crystals are larger and

* Considerations on Volcanos, p. 267-8.

more numerous. The upper parts are also porous and cellular; while the interior of the rock is as compact, hard, and crystalline as granite. Indeed this stone is quarried for ornamental purposes,—such as columns,—taking an excellent polish, and when worked up being scarcely distinguishable from gray granite. Irregular fissures divide it into rude prismatic masses. Blocks of a dark-coloured and dense pumice, of porphyritic pitchstone, and pearlstone of a dull greenish colour, occur among the ejected fragments strewn over the outer slopes of the cone.

One of the most interesting products of the chemical processes which are continually carried on by Nature in the Solfatara, but which has not to my knowledge been described by any of its visitors, is the abundance of globular concretions formed of concentric laminæ, which are created in the decomposed trachyte, evidently by the exertion of the affinities of some of its elementary molecules, to which the disintegration of the rock gave the requisite freedom of action. Other globular concretions, but of a more simple structure, (pisolites,) are common in the loose conglomerate of this and the other neighbouring hills, and owe their origin most probably to drops of rain falling on very finely comminuted volcanic ashes, and uniting them into spherical globules; a phænomenon that happened before my eyes on the surface of Vesuvius, during the rains which followed the copious showers of ashes thrown up by that volcano in October 1822. The Solfatara is recorded as having been in eruption A.D. 1180; and, if this account is to be credited, the present crater of this hill must have been produced at that late epoch. This idea is certainly supported by the great heat still evolved with the vapours from its bottom, and also by the occurrence of a small bed of a light and scoriform trachytic lava, of recent aspect, on the summit of Monte Olibano, resting upon the strata of loose tufa which cover the principal mass of trachyte. The whole hill in this case must have possessed a somewhat different figure from the present, when it bore the name of *Colles Leucogei*, though that name, and the early celebrity of its hot mineral springs, prove its phænomena to have but slightly, if at all, varied in the interval.

Next perhaps to the Solfatara in recentness of origin, we should rank the small hill called Capo-mazza, a cone of great regularity occupying the interval between that hill and the Monte Barbaro. It has a circular but shallow crater at the summit, nearly filled, indeed, by the washings from the very friable strata which encircle it. These, as well as the whole substance of the hill, consist of a loose conglomerate, composed of extremely silky, light, and fibrous pumice, and its detritus. Similar fragments are scattered thinly on the surface of the Monte Barbaro and the other neighbouring hills, covering a vegetable

mould, and were probably projected there by the eruption which produced the hill of Capo-mazza at no very distant period.

The cone of Astroni is remarkable for its wide and deep crater, surrounded by almost perpendicular banks; for the occurrence of a small parasitic cone in the middle of the flat plain which forms the floor of this cavity; and for the rock of trachyte, similar to that of Olibano, which shows itself on one part of the basin, cropping out from the conglomerate which composes the chief part of the cone.

The hills that encircle the Lakes Averno and Agnano have nothing peculiar in their constitution; consisting, like the last, of beds of loose feldspathose conglomerate containing large blocks of pumice. The Lago d'Averno was fathomed during my residence at Naples by Captain Smith, who had the kindness to communicate the result to me. It appears to be from 100 to 102 feet in depth; beginning to shoal in gradually on all sides, at a distance of about forty feet from the bank. The Lago d'Agnano is a much larger and, I believe, shallower basin: but there is little reason to doubt its resulting equally from volcanic explosions; though the hills thrown up around appear to have been much defaced, and their declivities smoothed by meteoric agency, and perhaps also by the addition of ejected matter from other neighbouring vents. There is a strong resemblance between this lake-basin and that of Kloster-laach near Andernach, which is however somewhat larger. The Lago di Ronciglione in the territory of Viterbo is another very similar cavity, and encircled by hills of precisely the same aspect and structure. All are evidently craters produced by the sudden and rapid explosions of a paroxysmal eruption.

The Monte Barbaro, (the *Gaurus inanis* of Juvenal,) though one of the largest and highest cones of the Phlegræan fields, is nevertheless evidently the product of but a single eruption. The crater is extremely deep and large, about a mile in diameter, circular, and perfect, with the exception of two breaches exactly facing one another, on the east and west,—which, however, do not penetrate half-way down to the flat and cultivated plain that occupies the bottom of this remarkable cavity. The rent to the west fronts the Monte Nuovo, and was probably caused by some convulsive shock attendant on the eruption of 1538. Monte Barbaro is composed throughout of indurated tufa, stratified in a direction exactly conformable to its surfaces both internal and external, and therefore dipping away on either side of a supposed vertical and cylindrical band dropped from the ridge of the cone.

The hill, on the summit of which stands the convent of Camaldoli, to the north of Naples, is still higher than that last described; measuring 1643 feet

from the sea. It is, however, by no means so regular in form or structure. There are appearances of a crater on the side towards Naples, but the thick woods, with which its slopes are covered, render this indistinct. The opposite side facing the north presents a very steep escarpment; at the foot of which, near the village of Pianura, a massive bed of trachytic lava, covered with a thick layer of loose conglomerate, crops out from under the prodigious thickness of indurated tufa which composes all the upper part of the mountain. This rock is quarried copiously, being in great request at Naples for steps, flagging, jambs, and all purposes which require a harder material than the tufa. It is known there by the name of *Piperno**. The galleries pierced for the extraction of this stone, run a considerable way under the hill. It is an earthy and porous trachyte of a dark ash-gray colour, of which the base is composed almost entirely of crystals of felspar, with a very few of augite, but is interspersed in a remarkable manner with lenticular or flattish masses; of a much darker and harder substance, in which augitic matter predominates, and of which the texture is close-grained, and structure cellular. It would seem that there has taken place throughout this lava a concretionary separation of the augitic from the felspathose particles, apparently analogous to the process by which flints are formed in chalk, or lenticular nodules of marl in clay. The difference of texture and structure between the parts is to be accounted for by the difference in the size of their grain; the augitic matter being fine, the feldspathose coarse; owing to which, the latter remain separated by pores or rude interstices, while the former was sufficiently liquid to allow of the formation of vesicles. The augitic concretions are lengthened, as was observed by Brieslak, in the direction in which the lava appears to have flowed;—a fact which proves the concretionary process to have taken effect before the lava had settled completely in its present situation.

A trachytic lava with nearly the same characters, and aptly illustrating this peculiar internal modification of the piperno, is met with amongst the products of the neighbouring volcano of Rocca-Monfina near Sessa and St. Agata, and likewise at Sorrento. In these places the feldspathose base of the rock is still more earthy, porous, and loosely granular than at Pianura; so much so, indeed, as to be with difficulty distinguishable from tufa; and the augitic concretions are also more fine-grained, compact, and vesicular, so as to resemble spongiform scoriæ. It is obvious that, in proportion to this difference in bulk of the

* This must not be confounded with the term *Piperino*, which is appropriated to the conglomerate of a leucitic rock, of volcanic origin, which occurs at Albano and other points in the neighbourhood of Rome.

respective mineral particles of the lava, will have been the facility afforded to the minute augitic matter to agglomerate, by a sort of drainage through the coarse, porous, and loosely aggregated mass of felspar crystals*.

The rock which formed the Acropolis of that most ancient Greek city, Cumæ, has in the wear and tear of ages, lost the characteristic figure, but still retains the structure, of a volcanic cone. From the midst of the tufa of this hill a massive rock of trachyte emerges, which varies very much in mineral character, being in some places identical with the rock of the Solfatara, in others a complete clinkstone. Parts are zoned with concretionary blotches and stripes of very different texture and mineral composition, like the piperno; and others pass into a breccia from the quantity of what appear to be enveloped fragments and nodular masses of variously coloured trachyte, resembling precisely on these points the rock of Lacco in Ischia.

To the south of Cumæ rises the Monte di Procida, a long ridgy hill composed of a trachytic conglomerate in irregular strata, which, on the sea-ward side, are observed to rest upon a thin bed of trachytic lava under peculiar circumstances. The colour of this rock is nearly black, notwithstanding its feldspathose nature, and that it fuses before the blowpipe into a light-coloured glass; its texture is earthy and porous, fracture uneven; it contains numerous very brilliant crystals of glassy felspar, and the interior of almost every block or division of the rock consists of porphyritic pitchstone, appearing to proceed from its partial fusion. No well-defined limit separates this lava from the conglomerate above, which, on the contrary, appears to pass into it by the fusion of its finer particles, and the torrefaction of the larger. The conglomerate envelops large loose fragments of granite and syenite. It would seem that this bed, or rather horizontal dyke, has either been originally of great extent, or that similar circumstances have produced the same peculiar appearances on three or four neighbouring points; for, at about three hundred yards distance, a rocky ledge rises from the sea, (called *Scoglio delle pietre arse*, The rock of burnt stones), composed of a pitchstone coated with earthy lava, and enveloping half-melted fragments of various kinds, exactly like that of the Monte di Procida; and the eastern angle of the island of Procida, immediately opposite and more than a mile distant, exhibits a similar bed, which is here seen to rest upon as well as to support the conglomerate, the whole being covered by stratified tufa.

The same island presents traces of three or four distinct craters, which have

* For other examples of this concretionary process in lavas, see the Paper on the Ponza Isles. Ante, page 195.

been much degraded, owing to its exposure to a heavy sea-swell both from the north-west and south. It appears composed throughout of a frame-work of indurated tufa covered with strata of the same substance in an incoherent state. One bed of trachytic lava enveloped in the tufa, is visible in the cliffs on the north-western side of the island *.

The promontory of Misenum has been once a very perfect cone with a regular crater, but the action of the waves has worn it away nearly to the centre, by which a fine natural section is afforded of the mass of indurated tufa of which it consists. The mantle-form disposition of the strata dipping away from the circular ridge, already noticed as characteristic of a volcanic cone, is no where better exemplified †.

The island of Nisida also is a small but very regular cone, with a crater into which the sea has at length effected its entrance, by a breach on the western and exposed side. The bluff cliffs disclosed by this continual degradation show the same internal structure as those of Misenum ‡.

Close upon Nisida rises the promontory of Pausilipo, a long and narrow ridge, connected with three or four similar hills called the Vomero, Capo di Chino, and Capo di Monte, which rise immediately behind Naples, and on a part indeed of which that town is built. All are composed chiefly of solid tufa, stratified mantle-wise; but though they partly embrace three or four decidedly crateriform basins, they have little of the regularity of ordinary cones. In the solid tufa quarried out of these hills I have found shells of the genera ostrea, cardium, buccinum, and patella, differing in nothing from the species that at present inhabit the bay of Naples: also pieces of unmineralized wood, retaining great flexibility of fibre, and burning with a slow flame and a resinous smell. The loose conglomerate of Capo di Chino envelops burnt and half-fused fragments of indurated tufa passing into porphyritic pitchstone, masses of this last substance with a minute globular concretionary structure (pearlstone), and others passing into complete obsidian; besides pumice, and a great variety of feldspathose lavas in fragments. At Capo di Monte vertical veins are observed to penetrate the hard tufa-rock. They are from six inches to two feet in width, and consist equally of tufa, but of a very fine grain, extremely hard, with a conchoidal fracture, and seamed with parallel stripes of a coarser grain. The appearance of these veins suggests the idea of their having resulted from fissures formed in the tufa before it was entirely consolidated, and filled by a deposit of its finest particles, from the water that exuded into the cleft from either side. Indeed the hard tufa, of which, as is

* See Plate XXXIV. fig. 6. † Ibid. ‡ See Plate XXXIV. fig. 4.

seen from the foregoing account, the volcanic hills of the neighbourhood of Naples are almost exclusively formed, seems evidently to owe its coherence, like the trass of the Rhine provinces, to a setting, or aggregative process which took place in a body of finely triturated trachyte intimately mixed with water, as that fluid drained off, or was squeezed out by the incumbent pressure. In the formations under review, this admixture with water appears to have been owing to the circumstance of the volcanic vents having burst out under the level of the sea, though in so shallow a spot that the accumulated ejections soon raised the cones to a certain height above the water-level; in consequence of which the materials subsequently thrown up, falling dry on the surface of the newly-raised island, remained in a loose state. Every one of the hills in question is indeed covered to a greater or less depth by strata of loose tufaceous conglomerate, conformable and sometimes graduating into the hard tufa below. The Monte Nuovo, which was thrown up in the middle of the Lucrine lake, has, like the other hills, a foundation of indurated tufa covered by loose conglomerate. The same loose arenaceous conglomerate, but evidently stratified by water, composes the flat spaces between the volcanic hills, and also the surface of the whole plain of the Terra di Lavoro, up to the foot of the Apennines; penetrating even their principal valleys to a considerable height,—as for example those of Maddeloni, Caserta, &c.,—having to all appearance been drifted there by the sea at a time when it washed the base of that chain.

It seems then that this part, at least, of the western coast of Italy has suffered an elevation of some hundred feet since the epoch of eruption of the greater number of volcanic mouths whose products we have been employed in examining, and which are certainly much more recent than the tertiary or subapennine formation. In this elevation, it is at least *probable* that the whole chain of the Apennines shared; and indeed there are traces of it in the limestone cliffs of the Monte Circello and the Calabrian coast, which are in some parts thickly perforated by recent lithophagi at a height of more than a hundred feet from the present level of the sea*.

Whether this elevation took place at once, or by successive heavings accompanying the earthquakes which have habitually affected the Western Apennines, from Rome to Palermo, is a question which it requires further inquiries to elucidate. From my own observations, I should be inclined to doubt that any sensible change has taken place in the relative level of the land and water round Naples since the Roman æra, (the few facts which have been brought forwards to support the idea of such change being contradictory, and to be

* See Brocchi, Cat. rag. passim. and Bibl. Ital. 1822.

otherwise explained); and for this reason I should prefer the conclusion,—that the rise of the plains of Campania from below the sea was produced by some convulsive crisis of subterraneous expansion, occasioned perhaps by the long obstruction of the superficial vents,—those natural safety-valves that by their occasional activity at present, may be supposed to obviate the recurrence of such tremendous operations.

The south-eastern side of the bay of Naples likewise contains some scattered volcanic formations. They show themselves in the recesses of the limestone mountains, both at Vico and Sorrento. No crater or regular cone is discoverable; but unequal deposits of tufa enveloping massive beds of trachytic lava, of an ash-gray colour, extremely light, porous, earthy, and brittle, show themselves on many points; particularly around Sorrento, where they form a plain backed by a crested range of limestone, and appearing to have been levelled by the action of the sea, though it is now raised more than two hundred feet above the actual shore,—an additional fact in favour of the recent elevation of this line of coast.

At the Punto di Campanella, the extremity of this promontory (which is itself composed of a sandstone, probably the new red, cropping out from below the great formation of Apennine limestone near Massa), another deposit of tufa is met with, which contains masses of obsidian coloured with various shades of blue, and frequently showing the small globular concretionary structure (pearlstone). The globules are concentric, but not radiated.

XXIII.—*Supplementary Remarks on the Strata of the Oolitic Series, and the Rocks associated with them, in the Counties of Sutherland and Ross, and in the Hebrides.*

By RODERICK IMPEY MURCHISON, Esq., Sec.G.S. F.R.S. F.L.S.

[Read Nov. 16th, 1827.]

HAVING revisited the district of Brora and those other tracts in the Hebrides which I described in a memoir published in the Transactions of the Geological Society*, and, upon this latter occasion, having enjoyed the advantage of Professor Sedgwick's company, I am enabled to make some further observations, and to present many illustrative fossils, in addition to those noticed in the former list; which serve to confirm the existence and order of superposition of the strata of the oolitic series.

I must, however, preface these observations by a few remarks on the structure of the crystalline rocks which flank these secondary deposits on the east coast of Sutherland.

Granite.

The promontory called the Ord of Caithness, which constitutes the north-eastern termination of the deposits of the oolitic series in Sutherland, has been described as a "granitic rock, composed of much felspar and quartz, with a green substance in a decomposed state which may have been mica†." Now, although such is the prevailing character near its junction with the secondary strata, an examination carried on more in the centre of the mass has detected so many examples of well crystallized mica, that this rock must be considered a true granite‡.

In the previous memoir I stated, that wherever this rock comes in contact with the beds of the oolitic series, the latter are compounded into a remarkable breccia: and recent observation has not only fully confirmed the conclusion which I drew from these phænomena; viz. "that the granite of this

* Ante, page 293. † Page 294.

‡ This rock of the Ord has been described by Professor Jameson as "compact granite composed of felspar and quartz."—*Mineralogy: Scottish Isles.* p. 259.

coast must have been elevated at a period subsequent to the deposition of the oolitic strata*," but has also led Professor Sedgwick and myself to the conviction, that it has been upheaved in a solid form, and that, in breaking through those submarine deposits which might not perhaps have been originally in contact, it has so fractured and dislocated their beds as to have prepared them for reconsolidation in the state of a brecciated rock.

At the Ord of Caithness this granite occupies a vertical cliff upon the coast for nearly two miles, throwing off the old red conglomerate on its northern flank towards the plains of Caithness; whilst to the south it forms a lower and broken cliff somewhat within the sea line, and which occasionally protruding on the shore, exposes upon its edges the brecciated rock. This breccia is exclusively derived from the oolitic series of this coast, the fragments of which, consisting of shale, sandstone, limestone, and fossil organic remains, are united into a compact mass by a calcareous cement; which, near the Ord, has a stratified appearance, rising from ledges below the tidal level to the height of fifty or sixty feet in the cliff, and dipping S.E. at a high angle. Thence to Navidale the shore is formed of the breccia, and the cliff of granite; but the latter is here so decomposed as to assume the general character which induced me to apply the term "granitic rock" to the whole.

The higher portions of the cliff are covered by thick diluvial accumulations derived from the primary mountains of the interior. In one situation, well crystallized granite protrudes upon the shore; and there the brecciated beds in contact with it are tilted at high angles, in various directions from the subjacent points of the crystalline rock; but as soon as the granite recedes inland, the regular strata (the fragments of which form the breccia) begin to occupy their regular places in the series exhibited on this coast.

The extraordinary appearances accompanying a contact of the granite with these deposits near Portgower have been cursorily noticed†; but they merit a more detailed description. The sandstone and shale rising from the shore at a moderate inclination, occupy both sides of a ravine, where the superior beds are first seen assuming arched and tortuous forms, apparently owing to irregular and fractured masses of the lower beds, which are driven upwards, and wedged vertically into overlying shale.

On further ascending the stream, all the strata on both banks from the base to the summit are observed to be broken up into countless fragments, and in one part to form a conical hillock resting upon the granite which is disclosed in the bed of the burn. These phænomena seem clearly to prove, not only that the granite has been elevated after the deposition of the overlying strata,

* Ante, page 307. † Ante, page 306. Pl. XXXI. fig. 2. Portgower.

but also that the amount of disturbance in the latter is proportioned to the degree of proximity of the former. Hence we might expect, that where the granite disappears, a more full development of the secondary strata would take place,—and such is the case in this district; for with the recession of the granitic ridge, the regular formations of the oolitic series, from the sandstone of the calcareous grit down to the base of the inferior oolite, are laid open, including the coal-field of Brora*.

Thin bands of primary slaty rocks are occasionally interposed between the granite and the secondary deposits along the inland boundary of the vale of Brora. These consist chiefly of a quartzose gneiss, and their occurrence in the chasm above Clyne Kirk has already been noticed†: they have since been observed in the bed of a small rivulet which falls into the river Brora near the loch of that name, where they dip E.N.E. 55°, are traversed by numerous veins of granite, and, as above Clyne Kirk, are here also surmounted by an unconformable mountain of red conglomerate.

Granite of the Sutors of Cromarty.

In my first visit to these remarkable elevated ridges I was unable to examine their structure in detail, being prevented by stormy weather from disembarking at various interesting points under their precipitous and rugged cliffs. I was, therefore, induced to employ nearly all my time in collecting organic remains from those detached beds upon the shore, which have, I hope, been identified with the lias of English geologists.

I have since ascertained that the portion of the Sutors which consists of primary rock, is chiefly a feldspathose and quartzose gneiss, much foliated, and generally nearly vertical; but in many situations so decomposed as not to be distinguishable from some varieties of the granite of the Ord of Caithness. This gneiss is associated with subordinate slaty rocks, hornblendic and talcose, and is repeatedly traversed by large and small veins of true granite.

Many writers have contended (and it seems now to be pretty generally admitted), that the granite must have been in a fluid state at the period when these veins issued from its mass; and others have further presumed that the

* When the granite recedes from the coast, the beds assume their natural and low degree of inclination, varying from horizontality to dips never exceeding 20°. In the previous memoir on this district and in the accompanying map, the angle of dip at Dunrobin, Strathsteven, and other places in the immediate neighbourhood of the coal-field, has been rated too high; whilst, on the other hand, where the granite approaches the coast at Portgower, some of the beds which form reefs on that shore are inclined at the high angle of 80° instead of 70°, as marked in the map. See Pl. XXXI.

† Ante, page 295. Pl. XXXI. fig. 1, 2.

gneiss must then also have been in a state of softness. But, in whatever mode these ramifying and tortuous veins in primary rocks may have been produced, a very different explanation is requisite to account for the fractured and brecciated beds of the oolitic series which accompany the elevation of the granite on the coast of Sutherland. There, it is evident, that the granite, when upheaved, could not have been in a fluid state, since it has neither penetrated nor overflowed the contiguous masses of solid breccia. In such situations therefore, the disturbing rock was, at the period of its elevation, most probably in a compact and crystalline form; in which case, when forced up against the overlying strata, it must have fractured the sandstone, limestone, and shale, thus preparing the materials which, when re-cemented, formed the breccia above described. But we have additional evidence of the elevation of the granite *en masse* upon this N.E. coast of Sutherland, where it has not only brecciated the beds of the oolitic series, but has also thrown up the red conglomerate to the summits of many of the mountains, whose bases consist either of granite or of gneiss charged with granitic veins. In these positions, the old red conglomerate which, when undisturbed, passes beneath the oolitic series, and its coal-field of Brora, presents that anomalous appearance represented in Pl. XXXI. fig. 2. which, without explanation, might lead to the supposition of its being an overlying deposit.

If an adequate cause be required to explain the great upheaving of the granite upon this coast, may we not seek for it in some deeply seated volcanic agency, struggling in vain to expand its forces from beneath the vast mass of primary rocks of which the mountains in the north-eastern Highlands are composed? In reasoning upon this subject it is worthy of remark, that no trap shows itself in association with primary rocks on the north-eastern coast. This is however no objection to the hypothesis here started, for trappean or porphyritic rocks may have acted upon the base of the primary mountains as disturbing agents, without traversing the superincumbent mass so as to appear on their surface. On the contrary, trap being developed to a prodigious extent among the *secondary* formations in the Hebrides and in the south of Scotland, may it not be presumed that these latter deposits, owing to their structure and their extent, were more easily traversed, altered, and even obliterated by igneous operations of which they afford so many indications?

Red Conglomerate.

I offer no additional remarks upon the varied relations of that widely extended conglomerate which succeeds to the oolitic series, as it will hereafter be treated of in detail by Professor Sedgwick and myself. But in relation to this

district I may here state, that the subdivisions, which we hope to establish, induce me to assign that portion of it which flanks the Brora coal-field to the old red sandstone.

Oolitic Series.

Denudation of Braambury and Hare hills.

The limestone and sandstone of these hills constituting the highest beds of the Brora district, have, by means of their abundance of characteristic fossils, been identified with the calcareous grit beneath the coral rag. I remarked in my former paper, that these hills probably owe their present form to denudation; which supposition is now confirmed by the exposure on their surface of innumerable parallel small furrows and irregular scratches, both deep and shallow,—such, in short, as can scarcely have been produced by any other operation than the rush of rock-fragments transported by some powerful current. Upon my first visit, these markings being only imperfectly visible in one situation near the quarries, I was unwilling to enlarge upon the fact; but Mr. Barton, the director of these works, has since cleared away the turf from other parts of the surface, and these operations have uniformly exposed similar phænomena. These hills have been swept free of all gravel, except on the N. and S. of E., towards which points the beds are prolonged into the plain of Clyne Milltown, where there is a thick accumulation of boulders of the old red conglomerate mixed up with the softer detritus of the denuded hills. The furrows and scratches appear to have been made by stones of all sizes, which (with the occasional exception of lines slightly diverging, probably occasioned by the smaller pebbles coming forcibly in contact with the larger,) preserve a general parallelism with a direction from N.W. to S.E.* By a prolongation of these lines into the interior, the boulders of red conglomerate may be traced from the plain of Clyne Milltown to the mountain range which is composed of that rock, and particularly to the precipitous escarpments on the south of Loch Brora. Although the dip varies much on the different sides and summit of the denuded hills, being about 20° north on their north-western flank, and only 10° E. near the quarries; still in all such situations the furrows and scratches preserve an uniform direction from N.W. to S.E.; thus indicating the great force of a current, unaltered in its course by any inequalities of the surface over which it rolled. These appearances so closely resemble those in other places described by Sir James Hall and Dr. Buckland, that further detail seems unnecessary; and the large slabs which I have had the pleasure of presenting to the Society, completely elucidate the case.

* By compass.

In the annexed tabular arrangement will be found a list of all the additional fossils which the district of Brora has afforded; and they will be found to confirm the comparison which has been established between these strata and those of the English oolitic series included between the calcareous grit of the coral rag and the base of the inferior oolite.

Western Islands.

Loch Staffin.—Skye.

Freshwater Formation.*

No indications of secondary strata in a higher part of the series than the upper portions of the great oolite had been noticed in my previous memoir on the coasts of the Hebrides: but, as masses of shale and other beds are found in elevated positions in the Isle of Skye, between the coast and the central chain of trappean hills of which the Storr forms the leading feature, it might be conjectured without further evidence, that some of these belong to a still higher part of the secondary formations. In confirmation of this opinion may be stated the important fact, that in the low and ruinous cliffs of blue shale associated with zeolitic and amygdaloidal trap on the north-eastern shores of Loch Staffin, were found during my late excursion with Professor Sedgwick flattened masses of shelly limestone containing five species of cyclas, one paludina, one neritina? one ostrea, one mytilus, and some undescribed bivalves. It adds materially to the interest of these remains, that two species of the cyclas, the paludina, and the ostrea, prove to be identical with the fossils of one of the upper beds of the weald clay described by Dr. Fitton as occurring in Swanage Bay, Dorsetshire, and in the Isle of Wight. Here, therefore, we have a decided indication of a formation of freshwater—or, at all events, of æstuary—origin, which had never before been traced north of Aylesbury in England; and this would seem to prove, that, although the continuity of such deposits may have been more limited in extent than those of marine origin, still the causes which gave rise to a deposit of the former class in England, may at the same epoch have been producing corresponding effects in the north of Scotland, and in other widely distant localities.

Oolitic Series in the Hebrides.

It has been already stated that the highest observed beds of the oolitic series, representing the cornbrash or forest marble, are traversed by several trap dykes at Beal near Portree in Skye. One of these, consisting of por-

* In the following pages the strata are described in their descending order. See Pl. XXXV.

phyritic greenstone, bifurcates upon reaching the summit of the cliff*. Professor Sedgwick and myself have since observed, that the extremities of the horizontal prisms of which the larger branch of this dyke is composed, consist of a dark green pitchstone, forming a band of about four inches in thickness, which, where not disintegrated, is seen in contact with the fossil limestone; the latter being apparently unaltered in its character. I am not aware that the existence of pitchstone in association with so recent a formation in Scotland has been hitherto noticed, and the fact is of importance in assisting us to limit the antiquity of those trap rocks which contain that mineral. In the Isle of Arran† it is extensively developed in the new red sandstone, from which formation it appears to have extended upwards through all the beds of the oolitic series in the Hebrides; for we again met with it at Carsaig on the south coast of Mull, forming the principal part of one of the numerous trap dykes, which there traverse the lias and inferior oolite. This latter dyke is about four feet in width, and is formed of horizontal prisms, the extremities of which consist of thin coats (two inches thick each) of blueish compact felspar rock, followed on either side by broader bands of greenstone, the centre being composed of about two feet of dark green porphyritic pitchstone; some veins of which penetrate through the exterior zones. Another trap dyke on this shore cuts through the lias, indurating the beds in contact, and sending out numerous veins, one of the largest of which envelops fragments of the lias shale including gryphites and belemnites. In this and many other situations, particularly in the cliffs east of Loch Buy‡, the presence of the trap seems to have converted the lias into Lydian stone, and the sand of the inferior oolite into a compact siliceous rock; whilst, in an equal number of cases throughout the Hebrides, the intrusive rock traverses the beds of these same deposits without producing the slightest alteration in them. The altered masses, however, chiefly predominate in those places where the masses of basaltic trap are of the greatest magnitude; as on the south coast of Mull, at the Inimore of Carsaig, or at the mouth of Loch Buy, and on the north-eastern coasts of Skye.

The organic remains collected on this last occasion in various parts of the Western Islands§, comprise many characteristic fossils tending to confirm the comparison already instituted, and to identify these deposits with the oolitic series and lias of English geology. If assiduous fossilists could devote

* Ante, page 310; and see Pl. XXXI. fig. 4.

† A memoir has recently been read before the Geological Society on the Secondary Strata of the Isle of Arran, in which Professor Sedgwick and myself have assigned the sandstone of the south-eastern and southern coasts of that island to the new red sandstone.

‡ See Pl. XXXV.

§ See the Supplemental Table, page 365.

a sufficient period to the examination of these coasts, they would find a rich harvest in those splendid cliffs on the north-eastern coast of Skye, which, between Portree and Holm, rise to the height of six or seven hundred feet, and also in those of Scrapidale on the S.E. coast of Rasay where the escarpment is equally magnificent;—both of which exhibit the several formations from the cornbrash down to the lias. In these localities the beds abovementioned are perhaps as fully developed as in any part of England: for the trap, which so generally obscures the stratification in the Hebrides, is here omitted; and the beds, being usually horizontal and little altered, afford a vast variety in their zoological contents.

It has been deemed impossible to load the pages of the "Transactions" with the numberless details which are exhibited in the detached coast sections of the Hebrides; but the following account of the succession of beds forming a part of the N.E. coast of Skye, may serve as an example of the kind of evidence upon which the conclusions of this and the preceding paper are founded. At the distance of nearly two miles from the valley of Beal, the high ridge of trap recedes from the cliff, and ranging round to the western flank of Holm, from Scoribrick to the Storr, leaves an elevated elliptical plateau about six hundred feet above the sea, of one mile and a half in length, and nearly half a mile in its greatest width. The whole section, as exhibited in the cliffs commencing at the western end of this plateau, and terminating at the level of the sea near the Prince's Cave, presents the following descending order.

1. Sandstone, appearing at the base of the trap, and also seen in the green talus sloping from it.
2. Shelly limestone, representing by its structure and organic remains cornbrash and forest marble, about forty feet.
3. Great white sandstone, fifty or sixty feet thick, overlaid by a thin bed of fissile shale. The lower beds more slaty, containing vegetable impressions, and passing gradually into
4. Shale and sandstone, alternating in bands, and forming another projecting terrace perhaps two hundred and fifty feet thick. Few fossils were observed in these beds, but much carbonaceous matter, and some obscure impressions of vegetables.
5. A lower calcareous zone, the upper beds of which (twenty or thirty feet thick) consist of calciferous sandstone, containing small nodules of indurated limestone grit with fossils, and having thin layers of shale with belemnites. The belemnites are also found in subordinate sandy beds.
6. Shale, dark blue, much more unctuous than the shale No. 4, containing many fossils of the inferior oolite, as belemnites, terebratulæ, &c., with small blue calcareous concretions, which mark the dip of the strata.
7. Base of cliff. Sandstone of inferior oolite with very large concretionary nodules of limestone, containing the pecten æquivalvis, ammonites Murchisonæ, &c.,—thirty feet exposed, shale of lias appearing below.

The beds numbered 5, 6, 7, may be considered as subordinate to the inferior oolite; No. 5 only differing from No. 7, in not having nodules of the same enormous size, and in exhibiting in its upper portion a passage into the carboniferous sandstone. Shale, No. 6, is thus decidedly included in the inferior oolite. These alternating beds of sandstone and shale are both in their mode of grouping, character, and contents, identical with the strata above the alum shale on the Yorkshire coast. All this section, from the great white sandstone, No. 3, which forms the principal projecting terrace of the plateau, is best seen at one view from a small waterfall, situated about half way between the Prince's Cave * and the western termination of the escarpment. This waterfall successively exposes each of the formations, and shows in a remarkably distinct manner the shale overlying the lowest or fossil beds of the inferior oolite.

The deposits of the oolitic series have further been observed extending to several localities where they had not been previously noticed. On the North-east coast of Mull, at or near Tobermory, the sandstone of the inferior oolite is quarried for building, and is seen resting upon lias, containing the Gryphæa incurva, the whole being overlaid by zeolitic trap. The same secondary formations are found on the mainland side of the Sound of Mull, in Morvern and Airdnamurchan, indicating a probable continuity at a former period with those of the islands. Lastly, we discovered lias limestone at Applecross, on the western coast of Rosshire, directly opposite to the great development of the same system in Skye, Rasay, and Pabba. At Applecross the beds rise from the southern shore of a small bay, at a gentle inclination, to the height of several hundred feet above the sea level, and repose upon the red-sandstone of the western coast, which here swells into very lofty mountains, the strata dipping to the N.W.

A section near the mill at Applecross exposes the following beds associated with the lias limestone.

No. 1. Beds of shale and sand slightly calcareous with many imperfect fossils;—one foot to one and a half.

2. Blueish limestone containing wood, pentacrinites, gryphites, ammonites, pinnæ, &c., with sand occasionally interposed;—two to three feet.

3. Calcareous gray gritty limestone, compact, quartzose, and void of fossils, but charged with veins of carbonate of lime;—four feet.

4. White conglomerate with quartz pebbles, cemented by calcareous matter;—three feet.

---

* One of the numerous stalactitic caves on the shores of these islands: it is said to have afforded shelter to the unfortunate Charles Edward.

No. 5. Impure calciferous gray gritty limestone.

6. Blueish limestone with a structure approaching to oolite. The laminæ coated with white calcareous powder.

The blue limestone, No. 2, occupies a part of the shore, where it forms a natural quay for the space of three or four hundred yards. In appearance and fossils, it is identical with that of Broadford in Skye. The calcareous conglomerate, No. 4, also agrees with a similar bed at Broadford, and is not to be distinguished from the white pebbly conglomerate in the lias at Shepton Mallet, Somerset, and the neighbourhood of Bristol; whilst the oolitic blue limestone, No. 6, has a precise equivalent in beds of lias at Cowbridge, Glamorganshire *.

These beds at Applecross are of high geological interest, and lead us to suppose that they must have been, at one period, connected with the similar analogous deposits in the opposite islands, which have been already noticed with great accuracy of detail, by Dr. MacCulloch, in his "Western Islands."

There are, however, some beds in Lucy Bay, Skye, belonging to the very lowest part of this series, which, although agreeing in position, and in some of their characters, with those just described, still seem to claim a distinct enumeration, from a peculiarity of composition in some of them, and from their containing very remarkable organic remains:—

No. 1. Upper beds of gray compact limestone of conchoidal fracture, alternating with thin courses of calcareous sandstone inclosing belemnites.

2. Thin beds of compact blue limestone with gryphites.

3. Thicker beds of grayish limestone, with bunches of polypifers of the genus astrea, which much resemble those of the madreporite limestone in the carboniferous series; but at the same time it must be observed, that, in the oolitic series of England, coralline bodies are occasionally found even in the lowest beds of lias, as, for instance, near Sodbury.

4. Calciferous grit.

5. Concretionary bed (two feet thick), containing a compressed mass of fossils, apparently those of the lias; the weathered surface of the rock displaying madrepores.

6. Greenish marly sandstone, passing into a yellow and green concretionary mass, which, on fracture, discloses large flakes of crystallized carbonate of lime.

The whole of these beds do not exceed forty feet in thickness; and, by their gentle dip to the N.W., they are carried under the dark-coloured mica-

* For the knowledge of the existence of oolitic lias at Cowbridge, Glamorganshire, I am indebted to Dr. Buckland, whose description of it, and also of the lias conglomerate at Shepton Mallet (Ante, vol. i. pp. 301, 303. N.S.), applies very aptly to the varieties of lias at Broadford, Lucy, and Applecross.

ceous shale of the adjoining island of Pabba. This shale appears therefore, from its position, to belong to the upper part of the lias ;—a conclusion which is strikingly confirmed by a most abundant suite of well preserved fossils, of which the greater number of the species have been identified as characteristic of that formation.

By way of concluding my remarks on the oolitic series of the Western Islands, it may be necessary to refer to the Section (Pl. XXXV.) which exhibits the succession of those deposits on the eastern coasts of Skye, from the highest beds in Trotternish in a descending order through the contiguous isles of Rasay, Scalpa, and Pabba, to the lowest lias limestone of Broadford and Lucy. In this section the overlying and intrusive trap rocks are entirely omitted, and the regular strata are alone represented. It is from this observed order, combined with the characteristic fossil shells in the several beds, that satisfactory evidence has been obtained for the establishment of the groups described in this and the preceding Memoir. At Applecross, only one small trap dyke has been noticed ; and the strata being there undisturbed, the lias is superimposed on the red sandstone of the west coast, in an order similar to that which has been described on the east coast near Cromarty. From these instances of junction, in situations so far distant from each other, it may be inferred that the lias and oolitic series of the North of Scotland succeeded generally to the red sandstone and conglomerate, occupying perhaps large tracts, of which isolated patches are all that now remain ; owing to the elevation of granite, the intrusion of trap, and various other operations which may have subsequently affected the earth's surface.

Since the publication of the former part of this memoir, two small patches of blue clay, one of which is about forty feet thick, containing organic remains, have been discovered overlying the red sandstone and conglomerate, in a ravine at Gamrie*, near Troup Head, Banffshire. Through the urbanity of Dr. Knight and Mr. A. Murray of Aberdeen, the Geological Society was furnished with a portion of these fossils ; they consisted entirely of fish, too imperfect to be

* I examined this coast in detail, Sept. 1826 ; but at that period the existence of these fossils at Gamrie was unknown, and they were only discovered in the subsequent winter by a great fall of blue shale, occasioned by the overflow of a mill-course. Professor Sedgwick and myself having in our recent excursion passed by another route to the south, we had no opportunity of examining the locality ; and I have therefore availed myself of the information communicated by the gentlemen named in the text.

identified, imbedded in calcareous nodules of a subcrystalline radiating fibrous structure. Better preserved specimens of these same nodular ichthyolites have since been forwarded to me by Mr. Christie, through Mr. G. Anderson of Inverness; and from an examination of these, Mr. Pentland has been enabled to give the following interesting description. "Among the ichthyolites of Gamrie," Mr. P. observes, "there appear to be at least two distinct species. The first, an abdominal fish, with a single dorsal fin, placed over the anal; characters which belong to the genus Esox of the older zoologists: to this character, which places the ichthyolite in the natural order Esocii, may be added, its large pentagonal scales, and that very peculiar structure of the caudal fin, in which the radii all arise beneath the vertebral prolongation; a character existing in the fossil fish of Caithness mentioned by Mr. Murchison *, and in the Lepisosteus among living species.

"The second ichthyolite is evidently also an abdominal fish, but of a very different species, if not of a distinct family; although the imperfect state of the specimens do not permit me to speak positively as to the relative position of the fins, or to judge how far the two species resembled each other in that very peculiar structure of the caudal fin observed in the former. This second species, however, possesses a combination of characters, which seems to distinguish it from all other ichthyolites I have seen; namely, having the fins covered with very fine quadrangular scales, a character employed by Cuvier to distinguish the family of Squamipinnæ in his Ichthyological arrangement. The scales on the body are disposed obliquely, as in the ichthyolites of Thuringia, and in those of the magnesian limestone of England; on the other hand, the bones of the head are covered with osseous papillæ or mamillary processes, as in certain species of Silurus, and in the fossil Dapedium of the lias. The elongated form however of this Gamrie ichthyolite, the minuteness of its quadrangular scales, and the scaly coating which covers its fins, offer characters sufficiently precise, even in these imperfect examples, to separate it from any of the species above referred to; and still further from any of the genera of recent or fossil fish described by the older authors. There appears to be also, in the same calcareous nodules, a third species of ichthyolite, much larger than either of those above mentioned, which is characterized by very large pentagonal scales; but no fins are discoverable, and to what family or genus it may belong, cannot be decided without more perfect specimens."

* See Geol. Trans. ante, p. 315. Baron Cuvier having now favoured me with an account of these Caithness ichthyolites, a full description of them, accompanied by engravings, will appear hereafter in a joint memoir by Professor Sedgwick and myself.—R. I. M.

In addition to the fossil fish, however, it would appear from the contents of a letter from Mr. Christie, that the blue shale of Gamrie has been also found to contain vegetable impressions and other fossil remains, of an obscure character; but these are not sufficient to enable us to determine the exact place of this deposit in our secondary series *: it gains, however, additional interest, from the fact that chalk flints, with their characteristic organic remains, had been discovered in considerable abundance on the granite of the neighbouring shire of Aberdeen near Peterhead; an important observation, first made by Dr. Knight, and afterwards verified by Dr. Buckland and Mr. Lyell.

* It is to be remarked that some of these calcareous nodules upon being broken transversely exhibit portions of galena.

SUPPLEMENTAL TABLE OF FOSSIL SHELLS.

The Figures refer to "Mineral Conchology," and the new species have been named by Mr. Sowerby.

List of Species and their Localities in	*Formations and Localities in which the same Species occur in*
SCOTLAND.	*ENGLAND.*
Braambury Hill quarries or highest beds in the Brora district, consisting of rubbly limestone and siliceous sandstone.	Calcareous grit and sandstone, or base of the coral rag formation.
Chambered Univalves.	
Ammonites, new species, much resembling A. cordatus	Shotover Hill, Oxon.
Belemnite (Cast of).	
Univalves.	
Melania Headingtoniensis. Tab. 39. . . .	Headington Hill, Oxon.
Bivalves.	
Lima rudis. Tab. 214. fig. 1.	Headington Hill, Oxon; Calne, &c.
Pecten fibrosus. Tab. 136.	Oxfordshire.
——— vagans. Tab. 543. fig. 3, 4, 5 . . .	Malton.
——— vimineus. Tab. 543.	Malton.
——— new species, with concentric laminæ (large shell).	
Trigonia, much resembling T. clavellata . .	Weymouth.
Terebratula ovoides. Tab. 100.	Figured from a specimen in gravel (Min. Con.)

SCOTLAND.	*ENGLAND.*
Reefs at Dunrobin, &c.	Oxford clay, shale, &c.
Bivalves.	
Gryphæa, differing slightly from G. obliquata. Tab. 112. fig. 3.	
Modiola, new species, longitudinally striated.	
Pecten, new species, striated.	
Plagiostoma duplicata. Tab. 559.	Malton oolite and cornbrash, Wilts, &c.
Terebratula media. Tab. 83.	Aynhoe, &c. Northampton.
A new species of gibbose shell resembling Unio.	
Venus, undescribed.	

Roof of coal, saltpans, &c.; Inverbrora.	Coal-field above the lias; East Moorlands of Yorkshire.
Bivalves.	
Cardium, new species (ribbed).	
Nucula, new species.	
Pullastra? large species.	

WESTERN ISLANDS.	*ENGLAND.*
Loch Staffin, Skye, blue clay and shale.	Weald clay? or some analogous Freshwater formation.
Univalves.	
Paludina, not figured	Weald clay; Isle of Wight, Swanage Bay.
Nerita or Neritina, not figured	Resembling Woolwich shells.
Bivalves.	
1. Cyclas media (Cyrena Lamarck), Tab. 527. fig. 2.	Weald clay; Sussex, Isle of Wight, and Swanage, Dorsetshire.
2. ——— larger species, not figured . . .	Identical with that found by Dr. Fitton, in Weald clay, Isle of Wight. (See Annals of Philosophy, Nov. 1824.)
3. ——— obovata. Tab. 162. fig. 4, 5, 6. .	Barton Cliff, Hants.
4. ——— new species, not figured.	
5. ——— new species, not figured.	
Ostrea, flat species, not figured.	Found with Cyclades 1 and 2 in the Isle of Wight.
Mytilus?	
A transversely elongated bivalve, not yet named or figured.	Weald clay, Isle of Wight. (See Annals of Philosophy, Nov. 1824.)
A bivalve referrible to Unio or Anodon.	

Oolitic Series.

Upper beds of shelly limestone, overlaid by sandstone (See page 321.)	Cornbrash, Forest marble, &c.
Pentacrinites.	Oxfordshire, Dorsetshire, &c.

WESTERN ISLANDS.	*ENGLAND.*
Great arenaceous formation, with subordinate beds of shale; the lower beds of sandstone containing very large nodules charged with organic remains.	Sand and shale of the eastern coast of Yorkshire, great and inferior oolite.
Chambered Univalves.	
Ammonites omphaloides, Tab. 242.	Weymouth.
——— new species.	
Serpulæ, Dentalia, Belemnites, &c.	
Bivalves.	
Astarte elegans? Tab. 137. fig. 3.	Babling Hill, Yeovil; Scarborough coast.
——— new species, unfigured.	
Avicula inæquivalvis. Tab. 244. fig. 2. . . .	Frethern, Gloucestershire; Kelloway, &c.
Gryphæa dilatata. Tab. 169. fig. 2. . . .	Kelloway oolite.
——— gigantea. Tab. 371. (E. of Carsaig, Scoribreck, Skye, Scrapidale, Rasay.)	Lias and inferior oolite.
Lucina crassa. Tab. 557. fig. 3. (also at Brora.)	Horncastle.
Nucula, unfigured.	
Plicatula spinosa. Tab. 245. (Scalpa, Scrapidale, Rasay).	Lowest beds of inferior oolite, and top of lias; Braunston Tunnel, Northamptonshire.
Trigonia, new species, approaching angulata . .	Oolite of Yorkshire coast.
Saurian tooth? associated with Ammonites, Terebratulæ, &c. (Scoribreck, Skye.)	

Micaceous shale and blue limestone.	Lias.
Chambered Univalves.	
Ammonites communis. Tab. 107. (Holm, Skye.)	Whitby, Lyme Regis.
——— Conybeari. Tab. 131. (Swishnish, Rasay, Carsaig, Mull.)	Lyme Regis, Bath, &c.
Bivalves.	
Gryphæa incurva. Tab. 112. (Carsaig.) . .	Whitby, Lyme Regis.
Modiola cuneata. Tab. 248. fig. 2.	Banbury.
Pecten, three new species, 2 striated, 1 plain. (Carsaig, Mull, Pabba.)	

WESTERN ISLANDS.	*ENGLAND.*
Plagiostoma gigantea, (Pabba. Tab. 77.) . .	Lias, Somersetshire, &c.
———— punctata. Tab. 113.	Pickeridge Hill.
———— new species. (Pabba.)	
Spirifer Walcotti. Tab. 377. (Carsaig, Mull.)	Pyrton Passage, Somersetshire, &c.
Terebratula punctata. Tab. 15. fig. 4. (Carsaig, Pabba.)	
———— tetraedra. Tab. 83. fig. 4. (Carsaig, Holm, Skye.)	Banbury, Oxfordshire.
———— new species (plaited), not figured. (Scalpa.)	
Polypifers of the genus Astrea.	Coralline bodies in the lias at Ledbury near Bridgwater.

Note.—I have the authority of Mons. Adolphe Brongniart for stating that he considers the fossil plant of the Brora coal, which Mr. König has described as Oncylogonatum carbonarium (ante p. 300), to be a species of Equisetum which he has named Equisetum columnare. It is figured in M. Brongniart's new history of vegetable fossils (vol. I. Plate XIII.), and will be described in the forthcoming number of that work. This plant, which appears to be generally characteristic of the inferior oolite, and which has never been discovered among the vegetables of the ancient coal measures, has been found at Balbronn, department of the Lower Rhine—in the neighbourhood of Stutgard—and even at Baldissero in Piedmont. Specimens from these localities are now in the museum at Strasburgh, and are all in the same compressed state as those in the shale at Brora.—R.I.M.

XXIV.—*On the Fossil Remains of two New Species of Mastodon, and of other vertebrated Animals, found on the left Bank of the Irawadi.*

By WILLIAM CLIFT, Esq., F.G.S. F.R.S. &c.

CONSERVATOR OF THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

[Read April 18th, 1828.]

IN describing the fossil remains collected by Mr. Crawfurd during his mission to the Burman Empire, and which his liberality has placed in the Museum of the Geological Society, I conceive that I shall best execute the task intrusted to me, by a strict adherence to zoological and anatomical detail; leaving all geological inferences to Dr. Buckland, who has undertaken that department, and who is so well qualified to do ample justice to it.

But before I proceed to my descriptions, it is necessary to express my great obligations to Mr. Broderip, the Secretary of this Society, for the very valuable assistance which he has afforded me on several important points connected with the subject.

In the arrangement of the materials before me, the system of Cuvier is followed, according to which I have first to treat of the

PACHYDERMATA.

Mastodon.

Fossil species of this genus have already been found in America and in Europe, and are so well known at the present day, that it would be superfluous to enumerate the various accounts which have been given of them. But I cannot pass over the "*Ossemens Fossiles*" of M. Cuvier, who has entered so luminously into the history of these extinct animals; more especially as he has, after describing M. giganteum and M. angustidens, given a chapter on certain teeth belonging to the genus Mastodon, which appear to him to indicate the existence of species different from those two which he had already recorded*. The teeth, according to the figures given, which come

* Ossem. Foss. tom. i. p. 266.

nearest to our specimen, are those figured as the teeth of "divers Mastodontes*;" and of these, the last figure referred to in the note forms the nearest approach to the first species which I have to describe. The teeth from which these figures were taken must have been much worn, and the last-mentioned figure, though at first sight it has the appearance of part of a tooth of our M. latidens, will be found nevertheless very different from it on a close examination, not only in the surface presented, but also in its comparative narrowness in proportion to its length. The teeth figured by Soemmerring are also deserving of notice†.

It was, however, reserved for Mr. Crawfurd to make us acquainted with the fact, that the remains of these extinct animals occur in Asia. To add to the interest of this discovery, the two species now about to be recorded are new, differing materially from every species of Mastodon hitherto described. On an examination of the structure of the teeth, this discovery will be found to have still greater claims to attention; for it illustrates very beautifully the gradual shades of difference by which Nature passes almost imperceptibly from one form to another, and helps to fill up the interval which has hitherto separated the Mastodon from the Elephant.

On comparing the teeth of our Mastodon latidens with those of the Mastodon of the Ohio (M. giganteum), we shall find the elevated points or ridges in the tooth of the former more numerous, less distant, and the interstices less deep than in those of the latter: in short, we shall observe that the teeth begin to assume the appearance of those of the elephant. On advancing to Mastodon elephantoides, we shall find all these features of similarity more strongly developed:—the points and ridges are still more numerous, and the structure, were it not for the absence of crusta petrosa, becomes almost that of the tooth of the elephant. In both, though the teeth are formed upon the principle by

* Ossem. Foss. Pl. 2. fig. 5. Pl. 3. fig. 2. and Pl. 4. fig. 4.

† Bemerkungen über einige in der Naturaliensammlung der k. Akademie d. W. befindliche fossile Zähne von Elephanten, Mastodonten, Rhinoceros'n und'einem Tapire. Vorgelesen am 10. Januar. 1818. von Samuel Thomas von Soemmerring. Tab. 1. 2.

M. Schintz, M.D. in giving to the Helvetic Society of Natural Science (August 1827) an account of the remains of Mammifera discovered in the coal mines of the Canton of Zurich, mentions "two kinds of teeth of the narrow-toothed mastodon" among those remains; and that "In the coal mine of Elgg, which has been worked about forty years, and of which the gallery is about 300 fathoms long, there have been found fragments of another species of mastodon which does not correspond to any of those described by Cuvier, and which has only a distant resemblance in form to the great mastodon."—"The large teeth," it is stated, "have always three rows of tubercles, the small two." "—a jaw and some bones of an undetermined species of mastodon taken from a colliery near Buchberg" are also mentioned. See the Edinburgh New Philosophical Journal, conducted by Professor Jameson, for Sept. 1828, p. 273, et seq.

which the tooth of the mastodon is distinguished from that of the elephant, the crown of the tooth wears away more like the tooth of the elephant than that of the other mastodons; and when worn, exhibits a surface not unlike that presented by the worn tooth of an Asiatic elephant.

These observations will not, it is hoped, be deemed out of place; for many a link in the chain which the zoologist who confines himself to the study of living animals only seeks in vain, may be found in the relics of a former state of animal life.

I now proceed to a description of the species, and shall begin with the character of

Mastodon latidens.—M. dentibus molaribus latissimis, denticulis rotundatis, elevatis; palato valde angusto.

Dentition.—Each tooth of the lower jaw consists of seven denticules, which are elevated, rounded, and mammillated: the mammillæ being from three to four in number. The dentition both in this species and in M. elephantoides, very much resembles that of the elephant. We have the molar tooth gradually protruded forward, and rising as the fangs are added, according to the demand made by the abrasion of the exposed crown, and the consequent absorption of the anterior fang; the posterior part of the tooth not having cut the gum, while the anterior portion is completely worn away. The relics of the preceding tooth, the place of which the tooth in use was progressively supplying, are plainly to be seen *.

The exposed grinding surface is considerably larger than that of the molar tooth of any elephant which I have seen, especially in breadth; and the enamel of the tooth is not so thick as it is in M. giganteum. And here we cannot fail to be struck with the similarity which the worn surface bears to the worn surface of an elephant's tooth.—The denticules are less elevated than those of other mastodons, and the whole form indicates an approach to the structure of the teeth of the elephant. The lower jaw too, in this species, is deeper and less angular than it is in M. giganteum; and approaches in its contour to the form of the lower jaw of the elephant. But on examining the cranium we shall find still stronger indications of an approach to the elephant; for the palate is so very narrow when compared with the palate of M. giganteum, as to strike the most casual observer †.

The tusks, judging from the alveoli, must have been of equal volume with the tusks of the largest living elephant. The portions of fossil ivory, however,

* See Plate XXXVII. fig. 1. Plate XXXVIII. fig. 2.

† See Plate XXXVI. and Plate XXXVII. fig. 1.

found with these remains, do not appear to have belonged to the individual which furnishes this description *.

Among the teeth of mastodons in the British Museum there are two or three which bear a strong resemblance to those of M. latidens; particularly one large molar tooth in a portion of the lower jaw. The anterior denticules of the tooth are worn away in precisely the same manner, and the worn surfaces are incrusted with the same kind of mineral cement as that adhering to many of the specimens brought home by Mr. Crawfurd. Its locality is unknown; its extreme length is nine inches, breadth three inches and five eighths; and it is composed of five denticules and the spur.

The only other remains which can satisfactorily be identified as belonging to this species, are fragments of two femora, of a tibia, a scapula, and a pelvis. The circumference of the lower extremity of the right femur round the condyles is two feet four inches.

The habits of this animal must have borne a close relation to those of the elephant. The proboscis must have been an organ of equal power with that of the elephant, for collecting the food to be subjected to the action of the powerful grinders; and this food (judging from the general structure of the teeth, and the more compact jaw bone,) probably consisted of harder vegetable matters than those which the slighter structure of the elephant's jaw usually encounters.

The size of M. latidens appears to have equalled, if it did not surpass, that of the largest living elephant. A string passed round the lower jaw, over the anterior part of the grinder where it is worn, measured two feet four inches; while a string passed round the lower jaw of the largest Asiatic elephant in the museum of the College, at the same point, gave two feet three inches; and the cranium of this elephant has always been considered a very large one.

Mastodon elephantoides.—M. dentibus molaribus latis, denticulis numerosis, compressis.

This species must have been smaller than the last; and though we have one fine example of the lower jaw, showing the tooth in the highest degree of perfection, that is the only portion of the animal from which we can safely draw any inference as to its structure and habits. The tooth, which is eleven inches long and three inches and a half broad, has no less than ten denticules, and each of these denticules is mammillated with small points; five being the smallest number, and eight the greatest on any one denticule. In front of this beautiful tooth we have a remnant of the preceding one, nearly worn down

* See Plate XXXIX. fig. 4.

and disappearing; and behind it, we have the cavity in which the young tooth which was intended as a successor to that in existence, must have been in the course of formation *.

The denticules of the tooth are much more compressed than those in the species last described; they are closer together †, and the enamel appears to be not so thick. They form a series of plates mucronated with small points. There is no apparent commissure, neither is there any central depression: on the contrary, the plates rather rise in the middle.

This tooth approaches still more nearly to that of the elephant, and the contour of the jaw is in unison with the appearance of the tooth. Perhaps we should not be far from the truth, if we were to conclude that the species to which this tooth belonged, formed the passage from the Mastodon to the Elephant. It is not impossible, however, that there may yet be a link wanting, which might be supplied by an animal having a tooth composed of a greater number of denticules, increasing in depth, and having the rudiments of crusta petrosa,—that necessary ingredient in the tooth of the elephant,—(for it is the animal mortar, as it were, by which the plates or denticules are cemented together)—the entire absence of which, distinguishes the tooth of the mastodon.

The habits of this species must have been nearly allied to those of the last. —But we must now leave this more interesting part of our subject, to consider the more common forms of the order now before us.

In this group we have remains of the genera Hippopotamus, Sus, Rhinoceros, and Tapir.

Hippopotamus.—Of this genus there are but few fragments, nor are they sufficiently characteristic to enable us to pronounce on the species, though there is no doubt as to the genus. The animal to which these remains belonged, must have been smaller than the recent species ‡.

Sus.—Of this genus there is only a single specimen, consisting of a small portion of the lower jaw, containing one molar tooth and the fragment of another. This species could not have been large §.

Rhinoceros.—Of this genus, we have, among other remains, a small portion of the upper jaw, containing two molar teeth; the remnant of the jaw is only just sufficient to hold the teeth together. There is likewise a single

* See Plate XXXVIII. fig. 2.

† Eight denticules of M. elephantoides occupy the same space as five denticules of M. latidens.

‡ See Plate XL. fig. 3. 4; and Plate XLI. fig. 19. 20.

§ See Plate XL. fig. 5.

molar tooth from the upper jaw: and there are also portions of the lower jaw containing molares, which seem to approach nearer to the rhinoceros of Java than to those of any other recent species *.

Tapir.—A fragment of the lower jaw, consisting of the symphysis, is the only remnant which can be safely attributed to this genus †.

RUMINANTIA.

The only fragments of ruminating animals in the collection, which can, in my opinion, be safely identified, are the portion of a lower jaw, and two or three separate molar teeth. They apparently belonged to an ox of ordinary size. There are other fragments, which are not sufficiently large and definite to warrant me in pronouncing upon the genera to which they belonged. There are teeth, fragments of cylindrical bones, and the bony cores of horns. The former may have appertained to a species of deer, and the latter have certainly the form of those of antelopes ‡.

Class *REPTILIA.*

CHELONIA.

Trionyx.—Both in the old and new world we have living specimens of this genus. In the rivers of South Carolina, Georgia, Florida, and Guiana, the Trionyx ferox lies in wait for birds and reptiles. It is called in some of the places where it abounds, the Duck-killer, from the ravages which it makes among those birds; while in others it is named the Alligator-turtle, from its predacious habits.

In Egypt, the Trionyx Ægyptiacus, which is about three feet in length, destroys multitudes of the brood of the crocodile at the moment of their birth.

But the largest recent species is said to be the Trionyx Javanicus. Individuals of a very large species, supposed to weigh between two and three hundred pounds, are said to have been seen in the Jumna and the Ganges.

No fossil trionyx has yet, it is believed, been found in North America; but the remains of a fossil species occur in abundance in the Hastings-sand and other localities in England, and in the Paris basin; and some are said to have been found in the diluvium of the South of France, accompanied by the remains of large tapirs. Fragments of trionyx in a fossil state are also found in other parts of Asia besides Ava.

The specimens from Ava leave no doubt as to the genus, but are not suffi-

* See Plate XL. fig. 1. 2; and Pl. XLI. fig. 16. 17. 18. 26, for other bones of this animal.

† See Plate XXXIX. fig. 5. and 5*.

‡ See Plate XL. fig. 6. 7. 8; and Plate XLI. fig. 27. to 33, and 21. to 25.

ciently defined to enable us to characterize the different species, which however must have been very large, and appear to have been not less than three.

Emys.—There are some fragments of a species, apparently of this genus. One, which is part of the sternum, indicates an animal of enormous size*.

SAURIA.

Fam. Crocodilidæ.

Of this family we have the remains of two genera; a Leptorhynchus, allied to, if not identical with, the great gavial (Lacerta Gangetica *Gm.*), and a crocodile resembling Crocodilus vulgaris. Of the former we have portions of the lower jaw, and several vertebræ. Of the latter we have vertebræ, and the anterior termination of the lower jaw, which must have belonged to a very large individual†.

It is worthy of remark, that most of the bones do not appear to have undergone any mineral change, with the exception of being abundantly penetrated with hydrate of iron, and that they are very brittle. This last circumstance, arising from the loss of their animal gluten, indicates that they are of great antiquity, and that they have not been imbedded in any very compact soil.

The teeth of the mastodon from the banks of the Ohio, which lie in a strong blue clay, have almost as much animal matter as we should expect to find in a recent tooth.

The bones which form the subject of this memoir are almost in every instance fractured; and the fracture,—from its direction and cleanness, the sharpness of its edges, and the firm texture of some of the bones,—appears to have been produced by a very great power operating with sudden violence.

It may not be deemed irrelevant, in closing this imperfect catalogue, to observe, that the remains before us indicate the existence of animals which could only have found subsistence in vast forests or widely extended plains, —in marshes, or deep and broad rivers. But the writer of this memoir feels it necessary only to advert to this subject, leaving the state of the globe at the time of their existence, and the period and cause of their destruction, to be discussed by those who are more competent to pursue so interesting an inquiry.

* Plate XLII. See the recent species of these genera described by Geoffroy, Ann. du Museum, tom. xiv. p.11—20; and their habits by Cuvier, Règne Animal, tom. ii. p. 10. 15. For the fossil species, see Cuvier, Ossem. Foss. tom. iii. p. 329; and tom. v. p. 322. † See Plate XLIII.

XXV.—*Geological Account of a Series of Animal and Vegetable Remains and of Rocks, collected by J. Crawfurd, Esq. on a Voyage up the Irawadi to Ava, in* 1826 *and* 1827.

By The Rev. WILLIAM BUCKLAND, D.D. F.G.S. F.R.S. F.L.S.
PROFESSOR OF MINERALOGY AND GEOLOGY IN THE UNIVERSITY OF OXFORD.

[Read April 18th, 1828.]

FOR the specimens and notes which form the subject of the present communication, the Society is indebted to the zeal and activity of J. Crawfurd, Esq., one of its Fellows, who having occasion to traverse the Burmese Country, on an embassy to Ava in the years 1826 and 1827, discovered an extensive deposit of organic remains in that unknown and distant region. He has brought home specimens of these remains, both animal and vegetable, as well as of the strata in which they were found, and has with much judgement and liberality presented them to the Geological Society of London, and to several other scientific Societies. It is on an examination of these specimens, and of the notes contained in Mr. Crawfurd's daily journal, that the observations and descriptions that make up the present memoir are founded.

Before I proceed to the details of this interesting subject, it may not be amiss to refer to the state of our knowledge, or rather ignorance, of the geology of these regions, antecedently to the discoveries of Mr. Crawfurd; an ignorance which our frequent and extensive intercourse with India has but recently and in a very slight degree tended to dispel; since with the exception of two Memoirs in the Geological Transactions*,—the one a paper by Mr. Colebrooke on the N.E. border of Bengal, the other a description of a collection of specimens made by Mr. Fraser, on a journey from Delhi to Bombay; and of two brief notices in the same volume,—no description of the secondary, tertiary, or diluvial formations of central and southern Asia, as compared with the similar formations of Europe, has been given to the public.

In the year 1823, in the following passage of my *Reliquiæ Diluvianæ* †, I quoted the opinion of Mr. Weaver on the importance of instituting a

* Vol. I. Part. 1. New Series. † p. 170.

comparison between the organic remains which might be discovered in the diluvium of tropical countries, and the similar remains found in the diluvium of the temperate and frigid zones of the northern hemisphere :—

"Another interesting branch of inquiry is, whether any fossil remains of elephant, rhinoceros, hippopotamus and hyæna, exist in the diluvium of tropical climates; and if they do, whether they agree with the recent species of these genera, or with those extinct species whose remains are dispersed so largely over the temperate and frigid zones of the northern hemisphere."

It could scarcely have been anticipated, that within so short a period as has elapsed since the date of this publication, the zealous investigations of a single individual should have gone so far as those of Mr. Crawfurd have done, to supply an answer to the questions then proposed.

The evidence which Mr. Crawfurd has imported, is derived from no less than seven large chests full of fossil wood and fossil bones, and of specimens of the strata that are found along the course of the Irawadi, from its mouth near Rangoon up to Ava, being a distance of nearly five hundred miles.

The larger portion of the fossil wood is beautifully silicified, and displays most delicately the structure and fibres of the living plants: in other specimens of it this structure is more obscure, though sufficient to show that the trees in which it exists were dicotyledonous. This obscurity arises from the fact of most of these dicotyledonous plants being impregnated with carbonate of lime, whilst all the monocotyledonous stems are silicified, as are also a few of the dicotyledonous: in these latter also the vegetable structure is more distinct than in the calcareous fossils, and in some of them it much resembles that of the tamarind wood. These plants were found most abundantly in the same region with the fossil bones, but occur also along nearly the whole course of the Irawadi from Ava to Prome. They were principally collected from a tract of country * extending over a square of more than twenty miles on the east bank of the Irawadi, near the town of Wetmasut, about half-way between Ava and Prome, between lat. 20° and 21°. N. The occurrence of bones was most abundant in a small space near the centre of this district, occupying about one third of the above-named area, the surface of which is composed chiefly of barren sand hills mixed with gravel; beneath these are strata containing shells and lignite, through which they sink wells about two hundred feet to collect petroleum.

In examining the bones, I have had the advantage of the co-operation of Mr. Clift, to whose anatomical description I beg to refer my readers†. And though we are still without proof as to the existence of fossil elephants

* See annexed map, Plate XLIV.

† And see Plates XXXVI. to XLIII.

in Asia, there being no remains of these animals in the collection now before us; we have bones and teeth of the Pachydermata which are usually associated with them in Europe, America, and Siberia; viz. of rhinoceros, hippopotamus, mastodon, tapir, and hog; also several species of Ruminantia, resembling oxen, antelopes or deer; with the addition of the gavial and alligator, and species of the two genera of freshwater tortoises, viz. Trionyx and Emys.

The occurrence of such reptiles in the same deposits with the Mammalia, has, I believe, not yet been noticed in the diluvium of Europe, America, or Northern Asia; and it deserves remark, that the gavial, and several of the Pachydermata found by Mr. Crawfurd, do not now inhabit the Burmese Country; for the gavial is now limited almost exclusively to the waters of the Ganges and its confluents; the hippopotamus exists no where but in the rivers and lakes of Africa; and the mastodon is utterly extinct. There is, however, no greater anomaly in supposing that all these animals inhabited the Burmese Country at the period preceding the deluge which overwhelmed it, than that at the period preceding the similar catastrophe which befel the North of Europe, the elephant, rhinoceros, hippopotamus and hyæna were co-inhabitants of England,—a point which in another work* I have endeavoured to establish from the evidence of the bones found at Kirkdale and in other caverns.

Judging from the number and proportion of bones in the collection made by Mr. Crawfurd, the most abundant fossil animal in the valley of the Irawadi is the mastodon, then the crocodile and tortoise, and lastly the rhinoceros and deer. Of the hippopotamus, parts only of two jaws have been yet identified; and of the tapir and hog, one fragment only of a lower jaw. It is not however possible to deduce any certain conclusions as to the relative abundance of these animals, from the proportion of bones in any single collection.

The following may be given as a rude approximation to the numerical proportion of bones and fragments of bones we have now before us.

	No. of bones.		No. of bones.
Mastodon	150	Ox, Deer and Antelope.	20
Rhinoceros	10	Gavial and Alligator	50
Hippopotamus	2	Emys	20
Tapir	1	Trionyx	10
Hog	1		

At the head of this list stand the remains of the genus Mastodon, not only because they so much exceed in number the aggregate of all the rest, but

* Reliquiæ Diluvianæ.

because they establish the fact, that at least two species of these gigantic animals were among the antediluvian inhabitants of the southern parts of Asia, and because they add, to the six species of this extinct genus already ascertained by Cuvier, two new and strongly characterized species, one of which, from its approximation to the elephant in the structure of the teeth, Mr. Clift proposes to designate by the name of *Mastodon elephantoides:* to the other he has given the name of *Mastodon latidens* *.

In the collection before us, there must be fragments of at least a dozen skeletons of mastodons, many of them equal in size to the bones of the largest modern elephant, and some exceeding them; the fragments of femur and tibia engraved in Pl. XLI. fig. 1. and 5. equal those of the largest fossil elephant, whilst in another specimen † we have the milk-tooth of a sucking mastodon. In other specimens of the teeth we observe various stages of advancement from youth to extreme age.

Of the ivory tusks of this animal, there are many small but decided fragments, of one of which a section is given at Pl. XXXIX. fig. 4. showing the intersecting curved lines, like the engine-turning on a watch, by which the ivory of the elephant's tusk also is characterized.

Of Ruminantia we have evidence to establish at least three species; viz. three different-sized condyles of the femur of three full-grown animals ‡; also teeth of at least two species of ox or deer or antelope §; and fragments of the solid bony base or core of three horns of antelopes ||; and two different tibiæ, with two different scapulæ of full-grown Ruminantia ¶.

The bones of gavial in this collection ** afford, like the hippopotamus, another example of the occurrence of fossil animals in a different locality from their recent analogues. Mr. Clift considers this species to resemble the existing gavials of the Ganges; but the frequent discoveries of fossil gavials in tertiary strata, and even in secondary strata, down to the lias, show, that in an earlier and different state of our planet this genus also has been dispersed abundantly and widely over its surface.

The specimens of alligators' bones also are scarcely sufficient to allow Mr. Clift to pronounce decisively as to their identity with existing species. From the magnitude of the fragments ††, their size must occasionally have been very great.

The fossil emys and trionyx of Ava we can scarcely identify, from our im-

* See Plates XXXVI. XXXVII. XXXVIII. XXXIX. and description by Mr. Clift.

† Plate XXXIX. fig. 1. 2. 3.

‡ Plate XLI. fig. 27. 28. 29.

§ Plate XL. fig. 6. 7. 8.

|| Plate XLI. fig. 21. to 25.

¶ Plate XLI. fig. 30. 31. 32. 33.

** See Plate XLIII.

†† See Plate XLIII.

perfect fragments, either with species that now inhabit the rivers of that country, or with the fossil tortoises which extend through nearly all tertiary and secondary strata; occurring in the tertiary sand-rock of Brussels, and in our London and plastic clay, in our Hastings-sand and Purbeck limestone, as well as in the Kimmeridge clay and Stonesfield oolite, in the lias of Glostershire, and transition slate of Glarus. In the modern rivers of India there are tortoises which attain a considerable size, and are cherished and fed by the natives.

It cannot but occur to us in this stage of our inquiry as remarkable, that not one fragment is found in all this collection either of the elephant, tiger, or hyæna, which now abound so much in India; whilst the mastodon, whose living analogue exists not upon earth, must probably at one time have swarmed in the districts bordering on the Irawadi. The same analogy which emboldened me in my first paper on the Cave of Kirkdale, to anticipate the discovery which was speedily made of hyæna's bones in the diluvium of England, arguing on the fact of their existence in the diluvium of the European continent, at the present moment encourages me also to anticipate the future discovery of the elephant, tiger and hyæna in the diluvium of Asia. I would also argue, on the same grounds, that it is highly probable we shall hereafter find the mastodon in our own diluvium and most recent tertiary strata.

The state of preservation of all these bones from Ava is remarkably perfect, from the circumstance of their being almost entirely penetrated with hydrate of iron, to a degree that has converted many of them to a rich mass of iron ore, and has given them a hardness which caused them, at first, to be considered as silicified; and they have been erroneously so described in some printed notices on this subject in the Calcutta Gazette, March 21st, 1827, and in other publications. Such, however, is not the case with any specimen I have seen in the whole collection; the cancelli of the bones are filled either with hydrate of iron or carbonate of lime, and their weight and strength thereby increased, but no other kind of change or injury to their external form has been produced.

It is in fact to the strength and indestructibility resulting from the mineral impregnation above mentioned, that we owe the discovery of these remains on the shores of the Irawadi. An accident that delayed for some days the steam-boat in which Mr. Crawfurd was descending this river, allowed him to land, accompanied by Dr. Wallich, and to investigate the structure of the country for some miles on the N.E. of Wetmasut. The accident arose from the shallowness of the water when the steam-boat was descending, which, fortunately for geology, caused it to run aground near the wells of petroleum,

where the left bank of the river presents a cliff of several miles in length, generally perpendicular, and not exceeding eighty feet in height. At the bottom of this cliff the strand was dry, and on it were found specimens of petrified wood and bones, that had probably fallen from the cliff in the course of its decay; but no bone was discovered in the cliff itself by Mr. Crawfurd and Dr. Wallich: nor were they more fortunate in several places where they dug in search of bones in the adjacent district. This district is composed of sand-hills that are very sterile, and is intersected by deep ravines: among the sand are beds of gravel often cemented to a breccia by iron or carbonate of lime; and scattered over its surface at distant and irregular intervals, were found many fragments of bone and mineralized wood, in some instances lying entirely loose upon the sand, in other cases half-buried in it, with their upper portions projecting, naked, and exposed to the air; they appeared to have been left in this condition, in consequence of the matrix of sand and gravel that once covered them undergoing daily removal by the agency of winds and rains, and they would speedily have fallen to pieces under this exposure to atmospheric action, had they not been protected by the mineralization they have undergone.

On examining many of the ravines that intersect this part of the country, and which were at this time dry, the same silicified wood was found projecting from the sand banks, and ready to drop into the streams; from the bottom of which the travellers took many fragments, that had so fallen during the gradual wearing of the bank, and lay rolled and exposed to friction by the passing waters. Some of these stems were from fifteen to twenty feet in length and five feet in circumference. These circumstances show that the ordinary effect of existing rains and torrents is only to expose and lay bare these organic remains, and wash them out from the matrix to which some other and more powerful agency must have introduced them.

Of the total number of bones in this collection, about one-third have suffered from friction; and of the remainder, nearly all appear to have been broken more or less, before they were lodged in the places where Mr. Crawfurd found them irregularly dispersed. Many fragments also of the ivory have been rolled considerably; but no one specimen of that substance, or indeed of any bone in this collection, has been reduced to the state of a perfect pebble: from this circumstance we may infer, that the waters which produced the rolling they have undergone, were not in violent action during any very protracted period of time.

Many of the larger bones and some of the small ones have masses of stone adhering to them, which afford specimens of the matrix in which they were

imbedded; these are composed of small round grains and pebbles of white quartz and various quartzose and jasper pebbles, strongly united together by a cement of carbonate of lime, and sometimes by hydrate of iron: where this iron is very abundant, it affords concentric ochreous concretions, resembling Aetites, dispersed irregularly through the breccia. The masses of calcareo-siliceous conglomerate that adhere thus to the bones, do not appear to have been separated by violence from any mass or stratum of solid stone, but to be merely small local concretions attached to these bones. There are other calcareous concretions that contain no kind of organic nucleus, but are composed of precisely the same materials as those which are formed around the bones, and present many of the irregular shapes of the tuberous roots of vegetables; some of them also have the elongated conical form of slender stalactites or clustered icicles, a form not unfrequently produced in beds of loose calcareous sand by the constant descent of water along the same small cavity or crevice, to which a root or worm-hole may have given the first beginning: some of these appeared in the cliffs just mentioned near Wetmasut. I have seen similar elongated and pseudostalactitic concretions disposed at right angles to the beds of sand, and descending vertically by the side of each other, like the roots of carrots and parsnips, to a depth of nearly two feet, displayed in the section of the cliff near Finale between Genoa and Nice, and I have also a collection of the same kind from the calcareous sand-beds of Bermuda; their form and position in the sand caused them to be sent home, under an idea that they were petrified roots*. Neither the insulated concretions from Ava, nor those adhering to the bones, contain traces of any kind of shells: they also differ mineralogically from all the specimens of tertiary and fresh-water strata in this collection.

Among the most remarkable of these strata is a fresh-water deposit of blue and marly clay, containing abundantly shells that belong exclusively to a large and thick species of Cyrena; and a dark-coloured slaty limestone containing shells which Mr. Sowerby has identified with some of those that occur in our London clay. There is also, from the hills opposite Prome, granular yellow sandy limestone containing fragments of marine shells, and much resembling the calcaire grossier of the environs of Paris; and from the same neighbour-

* Dr. Fitton, in his excellent account of some geological specimens from the coasts of Australia (London, 1826), describes many similar examples of stalactite-shaped and other irregular calcareous concretions, in the sandy strata that occur on many parts of those coasts. He also gives references to authors who have described similar cases in other countries; viz. to Dr. Mac Culloch, who has described them as existing in Perthshire, Dr. Paris in Cornwall, Captain Lyon in Africa, and other writers.

hood and other places higher up the Irawadi, are several specimens of soft and greenish sandstones resembling those of our plastic clay formation. From all these, it appears highly probable, that some of the most important component members of our tertiary strata occur along a great part of the course of the Irawadi, between Ava and Prome, near which latter place the alluvial delta begins, which extends from thence, by Rangoon, to the gulf of Martaban.

Throughout this district also we seem justified, by the notes of Mr. Crawfurd, in establishing the existence of the same distinctions between diluvial and alluvial deposits that are found in the valleys of all our European rivers. To the alluvial belong not only the immense deltas just mentioned as occurring from Prome downwards to the sea, but also a number of islands, that are continually forming and shifting at various places along the whole extent of the actual bed of the Irawadi, more particularly at Rabakyooktan, and also between the latitudes of 20° and 21° N. about half-way from Prome to Ava, between the towns of Wetmasut and Salè, in the neighbourhood of the fossil bones ; to the diluvial deposits we may probably refer the sand and gravel beds containing the mineralized bones, which, as Mr. Crawfurd has observed, it is impossible to attribute to the waters of the Irawadi, because they occur in a district where the stream is pent up within steep banks which it never overflows, and within which it never rises above twenty feet, while the average elevation of the ossiferous sand and gravel beds is at least sixty feet above the highest floods of this river. He further observes, that whilst the bones and wood of these comparatively elevated plains are mineralized, and converted the one to iron and the other to flint, the remains of modern trees and modern animals that are stranded on the alluvial islands of the existing river, (particularly on an island near Rabakyooktan,) undergo no such change, but are seen daily falling to decay and crumbling to dust : and he also mentions, for the purpose of disproving its correctness, that it is a popular notion among the natives, who have long observed the existence of this fossil wood, that it has been turned to stone by the waters of the Irawadi : such opinions are very natural on the shores of rivers and lakes where fresh pieces of fossil wood become continually exposed by the wearing away of the banks in which they were imbedded and received their mineral impregnation ; the waters of Lough Neagh in the county of Antrim are in the same way believed by the Irish peasants to possess the property of converting wood to stone*.

The facts in such cases are, that a succession of fresh pieces of silicified

* The idea is probably alluded to in the cry, which is said to have been at one time common in Dublin: "Lough Neagh! buy my hones,
Once were wood, and now are stones."

wood is found after storms exposed along the shores, being washed out of the banks that are continually wasting by the waves. The evidence before us then is such, that I believe no practical geologist will be disposed to assign the origin either of the wood or bones under consideration, to the comparatively impotent exertions of existing causes. The question reserved for him is, whether some of these remains may not also occur in the most recent tertiary strata, as well as in the diluvium of Asia:—the analogy of Europe would lead him to expect the same Mammalia in both; we have however in the specimens before us not one shell of any kind adhering to the bones, or in the agglutinated sand and gravel attached to them; and in Mr. Crawfurd's notes, there is no evidence to show that any bones were found, except in the deposits of sand and gravel near Wetmasut, and these differ materially from every specimen in his collection which we recognise as identical with the tertiary strata of our own country.

It is of course impossible for any person who has not been on the spot, to decide with certainty on a question which requires so much minute local investigation by a very experienced observer. I shall therefore conclude with recapitulating the only three speculations that I conceive can be proposed, to explain with probability the date and origin of the bones before us.

I. Either they were lodged in the most recent marine sediments of the tertiary formation, like the elephant in the crag of Norfolk, the rhinoceros of Placenza, and the mastodon of Dax and Asti;

II. Or in antediluvian freshwater deposits, analogous to those which contain the rhinoceros, elephant, hippopotamus and mastodon in the Val' d'Arno;

III. Or in diluvial accumulations more recent than either of these formations, and spread irregularly, like a mantle, over them both.

Now, as we find on careful examination of the matrix adhering to these bones, that it contains neither freshwater nor marine shells, and is wholly different in character from all the specimens which contain such shells, and which thereby enable us to refer them respectively to freshwater or marine origin; the most probable conclusion we can arrive at is, that the bones belong to neither of these formations, and that their matrix is of the same diluvial character with that in which the greater part of the fossil bones of Mammalia have been discovered in Europe.

Having proceeded thus far in our consideration of the nature of the bones before us, the time when the animals lived to which they belong, and the most probable causes that brought them to their actual place and condition,—we may now consider the evidence on which it has been asserted in the preceding pages, that the strata subjacent to the Burmese diluvium, along nearly

three hundred miles of the course of the Irawadi, from Prome to Ava, present a repetition of the geological structure of Europe.

From the examination of the specimens, compared with the notes in Mr. Crawfurd's journal, the following formations may be recognised with a greater or less degree of certainty.

1. Alluvium.
2. Diluvium.
3. Freshwater Marl.
4. London Clay and Calcaire Grossier.
5. Plastic Clay, with its sands and gravel.
6. Transition Limestone.
7. Grauwacke.
8. Primitive Rocks, Marble, Mica Slate.

There are also indications (but less certain) of new red-sandstone and magnesian limestone.

The Alluvium and Diluvium (Nos. 1. and 2.) have been already spoken of.

3. The Freshwater formation (No. 3.) occurs a little north of the Petroleum Wells and of the district in which the bones were found near Wetmasut, and is at an elevation of 150 feet above the Irawadi. The specimens of it consist exclusively of marly blue clay containing freshwater shells of the genus Cyrena: the shells are very thick and heavy, nearly three inches in diameter, and judging from the great quantity imported, must be extremely abundant; and, though accompanied by no other organic remains of any kind, are sufficient to establish an analogy, in the strata containing them, to the freshwater formations that occur associated with the tertiary strata of Europe. There is, however, no evidence to show any connexion between these freshwater deposits and the fossil bones or wood; from the portions of iron and gravel adhering to many of the remains of tortoise, crocodile and hippopotamus, it should seem that they had no connection with the freshwater deposit: still the abundance and size of such animals show that there must have been large rivers or lakes at the time and place in which they lived; though it would not justify our assigning them, without further examination, to the period in which these freshwater strata were formed that contain the shells of Cyrena.

4. We have from the hills near Prome a coarse-grained yellow shelly and sandy limestone, scarcely distinguishable from the calcaire grossier of Paris; and from several places higher up the Irawadi, particularly at Pugan, we have a dark bituminous slaty limestone, in which Mr. Sowerby has recognised the following fossils as identical with those of the London clay.

Ancillaria, Murex } Lamarck, Environs de Paris. Only found in London clay and calcaire grossier.

Cerithium, Oliva } London clay.

Astarte rugata. (Min. Conch.) London clay and calcaire grossier.
Nucula rugosa. London clay and calcaire grossier.
Erycina.
Tellina. London Clay:—shell figured by Brocchi.

Teredo. In blocks of calcareous wood: the same as in the London clay.
Teeth of shark. London clay.
Scales of fishes. London clay.
Pebbles of rolled black bone.
Unknown radiating fossil resembling coral.

This recognition of a stratum so nearly resembling the London clay in respect of its peculiar shells and other fossils, in so distant a part of Asia, receives still further interest when viewed in conjunction with the information that has been afforded to us by Mr. Colebrooke*, as to the existence of a similar formation at Cooch-Behar in the N.E. border of Bengal, where the Brahmputra emerges into the plain. Here Mr. Scott discovered strata of yellow and green sand alternating with clay, that lie horizontally at the height of about 150 feet above the level of the sea, and contain organic remains resembling those of the blue clay of the London and Hampshire basin.

Mr. Scott has also discovered at Robagiri, in this same district, a stratum of white limestone containing nummulites and vertebræ of fish, surmounted by beds of clay which contain the same nummulites, and also bones of fish, with shells of Ostrea and Pecten.

Near Silhet the Laour Hills, composed of white limestone loaded with nummulites, form another example of tertiary formations in the eastern extremity of this province†. And the section near Madras, given by Mr. Babington‡, shows the same tertiary formations to exist also on the western shores of the Bay of Bengal.

All these circumstances taken together, leave not a doubt of the important fact that the tertiary strata, which a few years since had been noticed only in the basins of Paris and London, are most extensively distributed over the surface of the globe. Their existence is now familiar to us in almost every state

* Geol. Trans. 2nd Series, vol. i. p. 135; and Plate XXIV.
† See Map, Geol. Trans. 2nd Series, vol. i. Pl. XXIV.
‡ Geol. Trans. vol. v. p. 337.

in Europe, particularly in the sub-Apennine formations, where they have been so ably described by Brocchi, and are now receiving further illustration from the able hand of Professor Guidotti of Parma. Again, we trace them round the shores and in the islands of the Mediterranean, at Montpellier and Nice, at Savona, Volterra, and Rome,—in the fish-beds of Mount Lebanon,—and the nummulite limestone that forms the foundation of the Pyramids of Egypt. We recognise them also along the northern shores of Africa, and in Malta, Sicily, and Sardinia. Mr. Strangways has traced them largely in the Steppes of Southern Russia, and on the shores of the Black Sea and the Caspian*. The Russians in their expedition to Bokaria have found them on the borders of Lake Aral; and now, on the authority of Mr. Crawfurd's discoveries, we establish them in a considerable district of the Burmese empire beyond the Ganges.

5. In many of the specimens from near Prome, we find a soft green and yellow sandstone resembling that of our plastic clay formation. Mr. Crawfurd describes these as associated with reddish clay intermixed with sand and pebbles, in words that are almost equally applicable to our English plastic clay-pits at Reading or Lewisham. He found them in many places where he landed along the shores of the Irawadi; and near Pugan † and Wetmasut they were associated with brown coal and petroleum, precisely as we find them containing brown coal all over Europe, and connected with wells of petroleum near Parma, and also in Sicily, and near Baku on the west coast of the Caspian. Near the petroleum wells of Wetmasut, Mr. Crawfurd also found large selenites resembling those that occur at Newhaven in our plastic clay. In Ava, as in Europe, they seem to be co-extensive with the clay-beds of the tertiary formation.

6. The transition limestone appears, from the few specimens we possess, to be of the same character with that of Europe, but in these specimens there are no organic remains. At a small hill four hundred feet high, called Manlan Hill, near Wetmasut and the petroleum wells, it is associated with grauwacke. There are also specimens of grauwacke much charged with carbonate of lime from so many distant points along the Irawadi, that, in the absence of better information, we may conjecture the fundamental strata of this region to belong to the transition series, and that they are covered more or less by the tertiary strata and diluvium which we have been considering.

* See his Map of European Russia, Geol. Trans. 2nd Series, vol. i. Plate II.

† On the west shore of the Irawadi, opposite to Pugan (see Pl. XLIV.), springs of petroleum ooze from hills composed of immense masses of blue clay; and if wells were dug, it might be collected as at Wetmasut.—*Mr. Crawfurd's Notes.*

7. From the mountains of the Sakaing Chain a little above Ava, we have much pure mica slate and statuary marble in its usual connexion with mica slate and hornblende rock; this marble is of the finest quality, and extensively employed by the natives in making images of Buddha.

The specimens afford no decided example of secondary rocks in this district*; but a reddish sandstone, which is used for architecture in the construction of thrones to receive the images of Buddha, and a limestone which resembles the magnesian limestone of England, may, I think, with more probability be referred to the new red sandstone than to any other formation.

The extent and relative position of all these strata it was impossible to ascertain from the few opportunities afforded to Mr. Crawfurd of landing from the steam-boat in which he made his voyage: these may become the subject of future investigations. The grand point is however established, of the occurrence of formations in the south-east of India analogous to the tertiary and diluvial formations of Europe, and containing respectively the remains of animals the same which the formations of Europe contain, or very similar to them: these animals must therefore at some time or other, and most probably at the same time, have existed in regions whose climate and inhabitants now differ so widely as those of India and Europe.

It must be confessed, in concluding, that the result of these discoveries, though intensely interesting, and a splendid example of what may be done by the skill and activity of one zealous individual, is rather to stimulate than fully gratify our curiosity; and to excite our hopes for more detailed and more extensive information from the future investigations of the most intelligent among our countrymen, whose professional duties call them to the eastern world.

Appendix.

Since this paper was read, I have been favoured by Dr. Fitton with the following communication, made to him by Col. Briggs, of a translation from an original Persian manuscript copy of Ferishta, in the library of the East India Company, procured from the library of Tippoo Sultan in 1799. The manuscript was transcribed in 1648, a few years after Ferishta wrote, and relates to the rise and progress of the Mahomedan empire in India. It con-

* Near Pukangyi

tains the following curious notice of the discovery of fossil bones near the town of Pinjore, N. lat. 30° 47′, E. long. 76° 54′.

"On the king's return to the capital in the month of Rejib 762 (May 1360), he heard that, in the vicinity of Perwar, was a hill out of which issued a stream of water that emptied itself into the Setluj river, which the people called the Sursetti, and that beyond it was a smaller stream denominated Selima.

"It was stated, that if an eminence which intervened between these streams were cut through, the waters of the Sursetti, falling into the smaller stream, would flow on to Sûnam, passing by Serhuid and Mausurpûr, and that the supply of water would be perennial.

"On this information, the king proceeded in that direction; and causing fifty thousand labourers to be collected, he employed them in cutting through the mound or hill, so as to form a junction of the two streams. In this mound were found the bones of elephants and men. The bones of the human fore-arm measured 3 gez, or 5 feet 2 inches in length. Some of the bones were petrified, others resembled bone."

Although from this ancient description it is quite impossible to ascertain the species of the animals to which these bones belonged, and quite certain that they were not human, it is evident from their magnitude that they were from some of the larger Pachydermata, but whether elephant or mastodon is not apparent, as we can impute no great skill in anatomy to the person who describes a human fore-arm 5 feet 2 inches long; still, the existence of the bones of any such gigantic species is an interesting addition to our knowledge of the natural history of India.

We of course can learn nothing from this account as to the geological position of these bones being in tertiary strata or diluvium: this is a question which even a modern geologist might find it difficult to determine, especially in cases where diluvial deposits rest immediately on tertiary formations. The case which in the present year occurred at Brentford, of bones of the elephant, hyæna, and other quadrupeds being found in the same excavation with the marine shells of the London clay, shows how much caution is requisite in geological observations of this nature. These bones were sent to the Society, accompanied by a report that they had been extracted from the London clay; and had the locality been in India, we should have been without means of correcting this information: but, on further examination of the spot, it was found (as had been stated on a former occasion by Mr. Trimmer*), that although dug from the same pits with the London clay, the bones had no

* In the Phil. Trans. 1813. p. 134.

other relation to it than that arising from the strata which contained them resting immediately upon this clay; in the same manner as the diluvial gravel containing similar remains of Mammalia near Oxford, rests immediately upon strata of the oolite formation, and near Rugby, rests upon lias.

Postscript.

While this paper was in the press, my attention was called to an extract in the Edinburgh New Philosophical Journal, [Sept. 1828,] from Lieut. Alexander's Travels in the Burman Empire, [London 1827,] stating, that during the late military operations at Prome, "the pioneers were ordered to remove a house; and upon endeavouring to cut down the massive teak pillars on which it was raised, they found that the edges of their hatchets were all turned. On examining into the cause of this, they found that the pillars were petrified throughout, though the house had only been built ten years, and the pillars were under water three months in the year during the monsoon."—Page 34.

This statement is so contradictory to the observations of Mr. Crawfurd, and to my own opinions, that I feel called upon to notice it in a few words.—We are told that the period of the submersion of these massive pillars was altogether but thirty months, and that in this short time they were petrified throughout; but it is not mentioned whether they were converted into silex or carbonate of lime. Now the most remarkable example we know of wood silicified by any existing river, is that of the piles of a Roman bridge over the Danube in Hungary, which are said to have become impregnated with silex to the depth of about an inch inwards from their surface, and this in a period of much more than a thousand years. In common cases of rapid incrustation by calcareous earth, the wood is simply incased with stony matter, and not penetrated by it throughout, as the pillars of Prome are stated to have been: the rapid petrifaction of these pillars, therefore, is so contrary to all experience and to theoretical probability, that I cannot but imagine that there must be some mistake in the information given to Lieut. Alexander upon the subject. Is it not more probable, either that the fossil trees which are so abundant in this district were made use of as posts to support the house in question?—or that the pioneers, on finding the hardness of the wood, were either impressed by the popular belief of the petrifying powers of the Irawadi, or took advantage of it to escape from their laborious task? Should these hypotheses be un-

tenable, and the pillars have been converted throughout into stone in ten years, and from this cause have defied the axes of the pioneers, they still exist, and may be appealed to in evidence of the fact: not only so, but the teak pillars of all buildings more than ten years old, that are within the flood level of the Irawadi, will also be converted into stone: it will be therefore easy to procure from Prome and send to London a portion of such a pillar, which would be decisive of the point at issue; but, as the country abounds in petrified trees, it should be remembered that no specimen will be satisfactory unless it is taken from a building the age of which is ascertained, and bears a form and marks that are unquestionably artificial and the effect of tools antecedently to the process of petrifaction.

XXVI.—*Description of Fossil Remains of some Animals from the North-East Border of Bengal.*

By J. B. PENTLAND, Esq. (In a Letter to W. H. Fitton, M.D. P.G.S.)

[Read May 2nd, 1828.]

My dear Sir,

THE researches in which I am at present engaged, having induced me to make some inquiries connected with the geological structure of the great mountain chains of our Asiatic empire, I was naturally led to examine the numerous and interesting series of Indian rocks in the Museum of the Geological Society.

My attention was particularly arrested by a collection of specimens from Caribari in the small state of Cooch-behar, on the banks of the Brahm-putra river, presented by Mr. Colebrooke, and described in his very interesting paper on the Geology of the N.E. border of Bengal,—since they afford the first example of the discovery of an extinct race of Mammalia in the great extent of Southern Asia; and at the same time furnish decisive proofs of the existence of tertiary marine deposits, perfectly identical in geological and zoological characters with those which cover so great a proportion of continental Europe and of our own island.

Among the mutilated fragments of bones referable to the order of Mammalia from the tertiary deposits of the Brahm-putra, I have succeeded in discovering the remains of four distinct species: viz. 1. One species of the genus Anthracotherium of Cuvier; 2. A small species of Ruminant allied to the genus Moschus*; 3. A small species of herbivorous animal referable to the order Pachydermata, but more diminutive than any of the fossil or living species; and 4. A carnivorous animal of the genus Viverra†.

1. The Anthracotherium of Caribari, in the form of its molares, possesses the characters belonging to the rest of the genus; but although some of the fragments which I have examined belong to a full-grown individual, the animal

* The occurrence of the teeth of "two ruminating animals, of which one is scarcely larger than the teeth of the small musk, and another belongs to a species of deer," in the tertiary coal of Zurich, is mentioned in the general account given by Dr. Schintz in August 1827 to the Helvetic Society of Natural Science, of the remains of mammifera discovered in the coal mines of that canton. See Edinburgh New Phil. Journal for Sept. 1828, p. 273.

† See Pl. XLV.

must have been one-third smaller than the lesser species discovered in the tertiary formations of central France, and of Cadibona near Genoa. We may therefore conclude that it forms a new species, to be added to the two already known, of the genus Anthracotherium; and I propose therefore to establish it as such under the name of *Anthracotherium Silistrense*, a specific denomination derived from one of the many names by which the great Brahm-putra river appears to have been designated by ancient geographers.

Mr. Colebrooke having already pointed out the analogies which exist between the deposits of Caribari and those of this island, it becomes unnecessary for me to enter into any detail respecting the other animal remains imbedded in them. I shall merely observe, that they present us with the same association of organized remains which accompanies the tertiary strata of Europe, in which extinct genera of the Pachydermata have been discovered; and that the marine shells found along with them are identical in genera, if not in species, with those which characterize the most modern antediluvian formations,—those described by MM. Cuvier and Brongniart under the title of upper marine formation in the Paris basin, and to which are to be referred the extensive marine deposits encircling the shores of the Mediterranean, which cover the less elevated countries of central Europe, and which appear to extend, as far as the Lake of Aral, into the interior of the continent of Asia.

The tertiary deposits of Caribari appear to form a band at the base of the Thibetian mountains, since we find them extending to Silhet, where they contain nummulites similar to those imbedded in the modern limestone of the pyramids; and of frequent occurrence in the tertiary calcareous rocks of northern Italy. How far the same formation may be prolonged in a southerly direction along the peninsulas of Malacca and of Hindoostan, it is impossible to say, although we possess proofs of its existence at Madras, where it contains the same species of shells as on the Brahm-putra; and at Pondicherry, where it envelops the great masses of silicified wood found near that city.

I may hereafter take an opportunity of presenting to the Society some further observations on this interesting subject. In the mean time I trust that you will receive this communication (which my occupations at this moment have prevented me rendering more detailed) with your usual indulgence; and not without some interest as connected with the recent discovery of gigantic remains of animals of the same order in another part of India.

Believe me, my dear Sir,

With great truth, yours very faithfully,

J. B. Pentland.

W. H. Fitton, Esq. M.D. P.G.S. &c. &c.

XXVII.—*On the Cycadeoideæ, a Family of Fossil Plants found in the Oolite Quarries of the Isle of Portland.*

By the Rev. WILLIAM BUCKLAND, D.D. F.G.S. F.R.S. F.L.S.
PROFESSOR OF MINERALOGY AND GEOLOGY IN THE UNIVERSITY OF OXFORD.

[Read June 6th, 1828.]

ABOUT twenty years ago I saw for the first time specimens of these fossil plants, in the collection of H. H. Henley, Esq. of Sandringham near Lynn. They had been procured by him from the celebrated freestone quarries of the Isle of Portland, where they were known to the workmen by the name of petrified birds-nests, their external form bearing a rude resemblance to the shape and size of a common crow's nest.

My attention has been recalled to this subject by a communication which I received in 1825 from Sir George Grey of Portsmouth, who transmitted to me a similar fossil found also in the Isle of Portland, and permitted me to make the drawings of it represented in Plate XLVII.

On my showing this specimen to Mr. Webster, he informed me that he had presented two similar fossils from Portland to the Geological Society of London*. There are also three more specimens in the museum of Mr. Sowerby, two of which he has kindly permitted me to engrave in Plates XLVIII. and XLIX. These specimens are all exclusively from the Isle of Portland.

The mineral condition of these plants is almost entirely siliceous, varying from coarse granular chert to imperfect chalcedony; it resembles that of the petrified trees which abound in Portland and often measure many feet both in length and circumference, in some of which Mr. Brown has recognised

* Mr. Webster informs me that he found these plants accompanied by large silicified trunks of dicotyledonous trees, in a stratum which he designates by the workman's name of Dirt-bed, being about one foot thick, consisting of a dark brown substance, and containing much earthy lignite; it lies immediately above the Portland building-stone, and divides it from slaty calcareous beds, which Mr. Webster doubts whether to refer to the Portland or to the Purbeck series. See Mr. Webster's paper on the Purbeck and Portland Beds, Geol. Trans. 2d series, vol. ii. Part I.

the structure of coniferous wood*. The limestone adjacent to these trees is itself pervaded by silex, and contains beds and nodules of chert.

On my submitting our new fossils to Mr. Brown and Mr. Loddiges, they immediately recognised a resemblance to the genera Zamia and Cycas, which compose the existing family of Cycadeæ, a resemblance which further investigation has tended fully to establish: and as their structure will be best explained by comparison with the recent Zamia and recent Cycas, I have given transverse sections of them both, wherein we find remarkable analogies to the two fossil species we are about to establish†. In the Zamia horrida of the Cape of Good Hope the transverse section exhibits one narrow circle, composed of radiating plates, placed in the cellular substance that forms the stem or body of the plant; and nearly at equal distance between its centre and circumference‡, and in a section near the base of Cycas revoluta§, we have two narrow circles of radiating plates, placed also in the cellular substance that forms the stem, and both of them nearer to the centre than to the circumference of the plant; the outermost of these circles is the most narrow.

Neither Zamia nor Cycas has any covering of true bark, but the stem is inclosed in a thick case made up of the persistent bases of decayed leaves: each of these terminates externally in a lozenge-shaped impression or scar, the convex surface of which formed the joint from which a leaf had fallen off. A dense and continuous series of these leaf-joints entirely surrounding the stem gives it more the appearance of a pine-apple or enormous fir-cone, than of a vegetable trunk||. On comparing these peculiarities of structure with those displayed in our fossil specimens, we recognise a correspondence highly curious and satisfactory. Like the recent Cycadeæ, our fossil stems are inclosed in no true bark, but have a thick case made up of the flat persistent bases of decayed leaves, which at their inner extremity touch the cellular tissue of the body of the trunk, and terminate externally in an oblong gibbous joint resembling the leaf-joints of Zamia horrida¶. These bases of leaves rise upwards,

* Dr. Fitton has recently discovered a fossil much resembling a small strobilus, about two inches long and one inch and a half wide, in the quarries of Quainton near Aylesbury, which are probably in the same formation as those of Portland.

† There are five known species of Cycas, and about seventeen species of Zamia, which Persoon has grouped together into the family of Cycadeæ. The difficulty that has attended the arrangement of this family from its intermediate place between the ferns, the palms, and the Coniferæ, to each of which it possesses certain points of approximation, and the discussions respecting it which still occupy some of the most eminent botanists of our day, give a peculiar interest to the discovery of fossil plants so nearly allied to the Cycadeæ as those which form the subject of the present memoir.

‡ Plate XLVI. fig. 3. § Ibid. fig. 1. || See Plate XLVI. fig. 4.

¶ See Plate XLVII. fig. 4.

and are most perfect near the summit of the trunk* : but lower down, the oldest of them lie horizontally and at right angles to the trunk, which they entirely encircle, and are more and more compressed as they are nearer to the root. In form, position, and structure, as far as it can be recognised, these parts resemble what we find in the recent Cycadeæ. As yet no leaves have been found adherent to any of the fossil plants. At the summit of most of them there is a cavity, the contents of which appear to have been removed before petrifaction took place : the relation of this cavity to the trunk and leaves may be seen by comparison with living plants of Zamia horrida, Cycas circinalis, and C. revoluta, referred to in the note †. Although the trunk is so tall in Cycas circinalis as sometimes to exceed thirty feet in height, it rarely attains six feet in Cycas revoluta, and in other species is much shorter. The trunk of many Zamiæ is also very short. In the fossil specimens yet discovered, it varies from five inches to a foot in height, and from eight to fifteen inches in diameter. Their different forms will be best understood by referring to the accompanying Plates ‡. They are generally terminated downwards by a broad flat base without any adherent roots ; but traces of the commencement of roots, having a cavity at their centre, are visible in Sir G. Grey's specimen §. At the base of other specimens there is only a coarse irregular reticulation, apparently connected with the commencement of roots. The interior of these stems presents two varieties of structure, which we find accompanied respectively by a corresponding variation of external form, size and character, in the bases of the leaves. These differences are sufficient, in the opinion of Mr. Brown, to establish a new family, to which we may refer the two extinct species before us, the one resembling a recent Zamia, the other resembling a recent Cycas ; and to which, from its near approximation to the existing family of Cycadeæ, the name of *Cycadeoideæ* seems appropriate.

In the largest and most abundant species (*Cycadeoidea megalophylla* ||) the bases of the leaves vary from one to three inches in length, having nearly the form and size of those of Zamia horrida, and measuring from one fourth of an inch to an inch in the shorter, and from one to two inches in the longer diameter of their transverse section. The trunk is short and flat, and exhibits a deep cavity at its summit resembling a bird's nest.

The origin and use of this cavity is rendered perfectly intelligible by com-

* Plate XLVII. fig. 1.

† See at Plate XLVI. fig. 4. a plant of Zamia horrida; and in Curtis's Botanical Magazine for June 1828, Plate 2826, a male plant of C. circinalis in flower; and in Transactions of the Linnean Society, vol. vi. Pl. 29. a female plant of C. revoluta in fruit.

‡ Plate XLVII. XLVIII. XLIX.

§ Plate XLVII. fig. 2.

|| Plate XLVII. and XLVIII.

paring it with that at the summit of the Cycas revoluta which bore fruit at Farnham in 1799, of which a description and plate are given by Sir J. Smith*. This cavity is surrounded with a magnificent crown of leaves, whose stalks are set round its margin like the bases of the leaves in our fossil specimen†. The cavity itself is occupied by a cluster of fronds producing the fruit or drupæ; and it is a striking coincidence, that Sir J. Smith, in describing this cavity, makes use of the same comparison (hollow like a bird's nest) which has been applied by the quarry-men at Portland to the fossils I am now associating with the recent Cycadeæ. In the central cavity of this fossil there are no remains of fronds or fruit, but a convex mass of cellular tissue, which probably formed the support of the proliferous fronds. Where the trunk is broken below the summit‡, we find the same central mass of cellular tissue as in the transverse section of the stems of recent Zamiæ and Cycades.

Near the circumference of both specimens there is a laminated circle as in the trunk of a recent Zamia, but differing in that it is much broader and placed nearer the circumference of the stem: the large and visible plates of this circle, when magnified with a lens§, appear made up of smaller plates almost invisible to the naked eye, more numerous and closer to each other than in the laminated circles of recent Zamia.

Between this radiating circle and the outer case of leaf-stalks, is a narrow band, or ring, of minutely cellular substance, analogous to the similar but much broader band of cellular tissue that divides the radiating circles from the bases of the leaves in the recent Cycadeæ ||.

In the second and smaller species (*Cycadeoidea microphylla*) the bases of the leaves are also lozenge-shaped and about an inch in length, but small and numerous, much like those of the Xanthorrhœa or gum-plant of New South Wales. The trunk is longer in proportion to its width, whilst its transverse section exhibits at the centre the same indistinctly cellular appearance as the species last described; but near the circumference instead of one it has two laminated circles, and exterior to each of these a narrow band devoid of laminæ, analogous to the two bands of cellular substance that are placed in similar relation to the two laminated circles in a recent Cycas ¶.

These two circles, like the one circle of *Cycadeoidea megalophylla*, approach the circumference, whilst those in Zamia and Cycas are placed nearer the centre of the stem.

* Transactions of the Linnean Society, Plate 29. p. 312.

† Plate XLVII. fig. 1. ‡ See Plate XLVIII. § Plate XLVIII. fig. 2. & 3.

|| See Plate XLVII. fig. 1. Plate XLVIII. fig. 1. & 3. Plate XLVI. fig. 1. & 3.

¶ See Plate XLIX. fig. 1. & 2; and Pl. XLVI. fig. 1.

There is also a further analogy between this fossil species and the recent Cycas *, viz. that in each case the outermost of the plated circles is the most narrow of the two, and the cellular band between them is in both cases also narrow.

The engraving of Cycas revoluta or Todda Panna†, copied from Vol. iii. Plate 21. of the Hortus Malabaricus, exhibits many plated circles divided from one another by narrow cellular bands, and these also are placed nearer to the centre than to the circumference of the stem.

It appears, therefore, that the external position and greater breadth of the laminated circle, or circles, in the Cycadeoideæ are the two most important distinctions that can be drawn from the specimens before us, between the structure of the stem in these extinct fossils and in the recent Zamia and Cycas. These distinctions also afford a character whereby this family approaches nearer than the Cycadeæ to the more perfect structure of dicotyledonous woods; and in this respect it may be considered to hold a higher place in the scale of vegetable creation, and to supply from the fossil world a link that helps to fill the distant interval which separates the structure of the trunk in the Cycadeæ from that in the nearest existing family to them, viz. the Coniferæ, which they perfectly resemble in the character of their organs of fructification. They however exhibit no traces of vessels such as radiate from the centre and form the silver grain in the more perfect kinds of wood ‡.

As yet, the stems of Cycadeoideæ have been observed in no other formation than the Portland stone, the geological position of which, in the upper part of the oolite series, is well known from the descriptions of Mr. Webster and of Messrs. Conybeare and Phillips, and no leaves have been noticed with them; but leaves of plants nearly allied, and perhaps belonging to this family, have been found near Whitby in the oolite formation, immediately above the lias, in the imperfect coal strata of the Cleaveland Moorlands; some of these are engraved by Messrs. Bird and Young §: others are in a collection from the same coal-field, made last year by Mr. Featherstonhaugh, and afford two

* Plate XLVI. fig. 1. † Plate XLVI. fig. 2.

‡ "Dans tout le règne végétal, il n'est aucune famille des plantes qui ait plus de rapports et de ressemblance avec les Conifères, que celle des Cycadées. Ces rapports nous semblent si grands, que nous pensons qu'il est impossible de distinguer ces deux familles, ni par des caractères tirés de leur fleurs, ni par des caractères puisés dans l'organisation de leur fruits. Les seuls signes distinctifs qui existent reellement entr'elles, consistent uniquement dans leur port et la structure anatomique de leur tige, que en effet est fort differente dans l'un et l'autre groupe."—*Richard, Mémoire sur les Conifères et les Cycadées.* 1826. p. 183.

§ Plate 2. fig. 2. and 7; and Plate 3. fig. 2. Geological Survey of Yorkshire Coast.

varieties of leaves resembling those of Cycadeæ, but which cannot be identified with any known species of that family.

M. Adolphe Brongniart also *, in his account of the coal-field of Höer in Scania, the age of which is decidedly much more recent than the coal of Newcastle, and probably identical with the oolitic coal-field of Whitby, describes the occurrence therein of fronds of four species of plants, that have an analogy to the family of Cycadeæ ; and are accompanied by other vegetables differing entirely from those of the regular and more ancient coal strata. There is also a strong resemblance to the Cycadeæ in some leaves I possess from the oolitic slate of Stonesfield.

From the same Stonesfield slate I have a fossil amentum called by Count Sternberg Conites Bucklandii, of which he has published a short account in his "*Flore du Monde Primitif* †," with a figure copied from a drawing by the late Mr. Sowerby. He describes it as a cone eight inches long and three inches in diameter, with scales most like those of the Pinus Abies, but not entirely agreeing with them, nor with those of any known species of cone ; and proposes to refer it to a new genus among the Carpolites. This Conites so much resembles the amentum of Cycas circinalis, which blossomed in Edinburgh in May 1827, and of which an engraving and description are given by Dr. Hooker in the Botanical Magazine ‡, as to induce me to believe that it may be the amentum of a Cycadeoidea ; but a much more minute comparison of the structures both of the fossil and of the amentum of a living Cycas than I have at present the means of making, must be undertaken before this point can be considered as established.

Thus dispersed through various members of the grand oolite formation or Jura limestone we have trunks and leaves, and perhaps organs of fructification, that may with much probability be all referred to our new fossil family of Cycadeoideæ. We have the trunks in Portland, the leaves at Whitby and in Scania, and both leaves and amenta ? at Stonesfield ; and though we are as yet without materials to show the specific relations of these parts to one another, we have evidence to prove the duration of one, or both, the cognate families of Cycadeæ and Cycadeoideæ to have extended from nearly the lowest to the uppermost beds of the oolite series.

M. Adolphe Brongniart has pointed out the inferences with respect to climate that may be drawn from the varying character of vegetable life in the three grand epochs of geological formation : viz. the great carboniferous

* Annales des Sciences Naturelles, vol. iv. p. 200.

† Part 3. p. 40. and Plate 30.

‡ For June 1828. Plate 2826.

period; the period of the secondary strata from lias to chalk inclusive; and the period of the tertiary strata above the chalk.

The plants before us render it probable that the climate of these regions, at the time when the oolites were deposited, was of the same warm temperature with that which produces a large proportion of the existing Cycadeæ. M. Adolphe Brongniart is also of opinion that it exceeded the temperature of our modern tropics at a still more early period when it maintained the extraordinary vegetation of the great coal formation; and that it was less than tropical, though warmer than it is at present, in the period to which we owe our tertiary strata. To this theory I see much reason to incline, and confidently look forward to its future developement in the examination of the Flora of the fossil world, which he is now so actively conducting.

Dr. Buckland's Supplementary Remarks on the supposed Power of the Waters of the Irawadi, to convert Wood to Stone.

London, October 29th, 1828.

I HAVE this day seen Dr. Wallich, and informed him of the Postscript added to my Paper on the fossil wood and bones from the Burman Empire, respecting the statement in Lieut. Alexander's Travels, that the teak pillars under a building near Prome had become petrified in the space of ten years, by the waters of the Irawadi during the monsoons. Dr. Wallich replied that, when he was at Rangoon with Mr. Crawfurd, they were informed by a British general officer, that there was at Prome an elephant shed, the pillars of which were converted to stone at their base. On arriving at Prome, they went to see this shed accompanied by the other gentlemen of the mission, and found its position to be above the flood level of the Irawadi, and that not one of its pillars had in any part undergone the smallest change from the natural state of wood.

In this case, therefore, as in that reported by Lieut. Alexander, it is probable that the officers had received without suspicion the current opinion of the natives, the universality of which may be referred to the constant use they make of fossil wood for weights and landing steps from the river. But the investigations of Mr. Crawfurd and Dr. Wallich seem decisive upon the subject: they were fully aware of the popular belief, that the soil of the country, as well as the waters of the Irawadi, have the property of rapidly converting wood to stone, and during the whole journey their attention was awake to every opportunity of verifying or refuting this opinion. Now I am informed by Dr. Wallich, that the bed of the Irawadi, all the way from Rangoon to Ava, was so thickly set with piles of wood that had formed the foundations of ancient temples, pagodas and sheds, that once at least, and sometimes more than once in every day, they were found to afford the steam-boat a more ready supply of substantial fuel than could be obtained from the shore; —in one case they were taken from water so deep that the steam-boat lay alongside of them during the operation of their extraction. A very large number of these pillars must, therefore, have been burnt during the voyage;

and the greater part of them had remained many years, and some of them probably hundreds of years, subject to partial or continual submersion in the waters of the Irawadi. Not the slightest trace of petrifaction was observed on any particle of all these pillars: and had it escaped the observation of the Botanical Professor, its presence (if existing) must have been detected in the fire. This evidence seems therefore not only to justify the assertion of Mr. Crawfurd,—that the waters of the Irawadi have no such petrifying power as the natives ascribe to them,—but also to confirm the opinion I have expressed in my Postscript, respecting the pillars of teak at Prome which are said to have been petrified throughout, in the short space of ten years.

XXVIII.—*Notices and Extracts from the Minute-Book of the Geological Society.*

1.—*Additional Remarks on the Nature and Character of the Limestone and Slate, principally composing the Rocks and Hills round Plymouth. By* the Rev. Richard Hennah, F.G.S. [Read Nov. 3rd, 1826.]

THE author refers to a former paper on this subject, in which he confined his field of observation to the narrow tract between the Plym and the Tamar. He now extends its limits to Mount Batten and Slatten Heights in a southerly direction. In this tract, which forms the east side of Plymouth Sound, as well as the western side from Mount Edgcombe to Pudding Point, animal remains are imbedded in the slate. On the eastern side the superior beds are occasionally of an ochreous clay-slate containing thin veins of iron with Trochites and stems of Encrinites: these are associated with some peculiar fossil remains, the characters of which are indistinct. The lower beds consist of compact white or light grey slate inclosing remains like those found in the limestone and slate. An ironstone bed occurs here which is used for pavements, and fragments of animal relics are discoverable in it.

From the above facts the author infers, that the slate which is prolonged beyond the Plymouth limestone, even as far southward as Whitesand Bay, is not primitive: but he remarks that he has never perceived animal remains in the slate north of that limestone.

2.—*Notice respecting a Whin-dyke in the Cooper Colliery, near Blythe, Northumberland; drawn up from the Information of* Mr. Bryham, *Agent at the Cooper Coal Works, by* W. C. Trevelyan, Esq., F.G.S. &c. [Read May 18th, 1827.]

The total length to which this dyke has been traced is 1377 yards. It increases in breadth from south to north; being $4\frac{3}{4}$ yards wide near the most southern point, where it has been cut through, and $21\frac{1}{4}$ yards wide at

the most northern spot hitherto observed. It is formed of two walls of greenstone, each from two to four feet in thickness; and these walls contain between them a breccia, composed of fragments of shale and whin, cemented by calcareous and argillaceous matter. Carburetted hydrogen and pure water issue from a narrow fissure in the broadest part of the dyke. The coal of the beds through which the dyke passes is charred, and deteriorated in quality, to the distance of about forty yards on each side.

3.—*Extract of a Letter from* Charles Stokes, Esq., F.G.S. F.R.S. &c., *to* William John Broderip, Esq., *Sec.* G.S., F.R.S., &c.; *explanatory of three Drawings of Echini.* [Read June 20th, 1829.]

1. A specimen of Galerites albo-galerus * (Lam.) from the chalk, in which the plates of the mouth, consisting of five pairs, are preserved *in situ*:—2. A Cidaris † also from the chalk, in which portions of the plates of the mouth and teeth are visible;—they are displaced, but exhibit a system quite analogous to that of the recent Cidaris: and 3. A Cidaris ‡ from Stonesfield, in which the anal plates are in the best preservation.

* Plate XLV. fig. 14 & 15. ‡ Plate XLV. fig. 16. † Plate XLV. fig. 17.

INDEX.

A.

Acropolis of Cumæ noticed, 349.

Actinocamax, Mr. J. S. Miller on the genus, 63.

———— conclusions as to the animal of, 67.

Ætna, eruptions of, noticed, 340.

Alcyonia in the chalk near Lyme Regis, 111.

——— in the sands and sandstones beneath the chalk near Lyme Regis, 113.

Alexander, Lieut., his account of the petrifying power of the waters of the Irawadi, 403.

Alice Holt, forest of, composed of gault, 100.

Alligator, fossil remains of, in the Irawadi district, 379, 380.

Alluvial delta between Prome and the Gulf of Martaban, 384.

———— contains recent bones and wood, 384.

Altered limestone of the oolitic series at the Ord of Caithness, 307.

Alton Hills, chalk escarpments of, 97.

Amentum, fossil, found at Stonesfield in slate, 400.

Ammonites brevispina, new species, Pabba, 322.

———— Gowerianus, new species, Brora, 320.

———— Jamesoni, new species, Mull, Skye, &c., 322.

———— Murchisonæ, new species, Holm, Skye, 322.

———— Sutherlandiæ, new species, Braamhury, Brora, 323.

———— other new species undescribed, 322.

———— new species, at Brora, 365.

———— and Terebratulæ, casts of? in the lowest beds of greensand near Midhurst, 102.

Anderson, J. Esq., his MS. Memoir on Brora, 293.

Antelopes, fossil remains of, found in the Irawadi, 374.

———— bones of, enumerated, 379, 380.

Anthracotherium, species of, from Bengal, 393.

———— in Central France, 394.

Apennines, probably elevated, 351.

Applecross, Rosshire, lias limestone and fossils of, 361.

Arenaria (Sandwort) of the black barren sand near Newbury, disappearance of where the sand had been chalked, 120 *note*.

Argillaceous slate in the parish of St. Mary, Jamaica, 153.

Arran, pitchstone in dykes, traversing new red sandstone, 359.

Ashburnham limestone and strata of Tilgate Forest, tabular arrangement of, with their organic remains, 131.

Astarte, new species of undescribed, Brora, 319.

Astrea, in lias limestone, Lucy, Skye, 362.

Astroni, hill of, described, 343, 347.

Augite in lava, 348.

Ava, Professor Buckland on the bones of the Mastodon, &c. from, 377.

——, mica-slate and statuary marble found near, 389.

Avicula Braamburiensis, new species, Brora, 323.

B.

Bakie Loch, comparison of limestone of, with other freshwater limestones, 83.

———— gyrogonites of, 91.

———— organic remains of the marl of, 77.

———— section of the beds of, 75.

Bald, Robert, Esq., his notice of the Brora coal, 293.
Banniskirk, Caithness, fossil fish in slate of, 314.
Bargate stone, 101.
———— quantity of calcareous matter in, 107.
Barytes, sulphate of, in the lias formation of Lyme Regis, 29.
Basalt, leucitic, composing the lavas of Somma, 338.
Beal near Portree, Skye, cornbrash and forest marble of, 310.
———————— trap dykes at, 310.
Beds resembling those at Kimmeridge in the Isle of Portland, 43.
Begelly, section at, 19.
Belemnites, Mr. J. S. Miller on, 45.
———— chemical analysis of, 56.
———— conjectures on the form of the inhabitant of, 56.
———— description of the species of, 58.
———— effects of decomposition on the shell of, 53.
———— generic character of, 48.
———— geological position of, 45.
———— structure of the sheath of, 51.
Ben-a-Bhraggie, Sutherland, composed of red conglomerate, 294.
Bengal, Bay of, western shores of, tertiary, 387.
——— description of fossil remains from, 393.
Bentley and Binsted, valley under, composed of gault, 100.
Benton Castle : *see* Trap.
Bird, fossil bone of a, in the east cliff at Hastings, 35.
Bivalves in the chalk near Lyme Regis, 111.
———— in the lias formation at Lyme Regis, 28.
———— in the sands and sandstones beneath the chalk near Lyme Regis, 114.
Bolton Beacon : *see* Trap.
Bones, fossil, discovered near the town of Pinjore, 390.
———— found between Ava and Prome, 378, 384.
———— fragments of, from Bengal, 393.
Bony substance, pieces of a, in the sands and sandstones beneath the chalk near Lyme Regis, 113.
Braambury, hills of, and quarries, 296.
———— fossils of, 297.
Brahm-putra river, animal remains from the, 393.
Breccia of the oolitic series in contact with granite, at the Ord of Caithness, 306.
———————————— produced by upheaving of granite, 354.
——— near Wetmasut on the Irawadi, 382, 383.
Broadford, Skye, lias of, same as that of Applecross, 362.
———— lias limestone of, 311.
Broad-haven : *see* Trap.
Brongniart, M. Adolphe, on the coal-field of Hoër, describes the fronds of four species of plants therein, 400.
———————— inferences with respect to climate, by, 400, 401.
Brora, coal-field of, 293.
——— coal of, described, 301.
——— coal strata, section of, 326.
——— coal works, history of, 324.
——— coast section of, 302.
Brown, Robert, Esq., notice of coniferous wood and fossil plants, examined by, 395, *et seq.*
Buccinum, new species undescribed, Brora, 320.
Buckland, Rev. W., D.D., on the formation of the valley of Kingsclere and other valleys, by the elevation of the strata that inclose them ; and on the evidences of the original continuity of the basins of London and Hampshire, 119.
———————— on the animal and vegetable remains, and rocks collected by J. Crawfurd, Esq., on a voyage up the Irawadi to Ava, 377.
———————— his visit to Brora, 293.
———————— on the Cycadeoideæ, 395.
———————— on the supposed power of the waters of the Irawadi to convert wood into stone, 403.
Buddha, marble and reddish stone used for making images at, 389.

Burmese Empire, organic remains discovered by Mr. Crawfurd in, 377.
——— strata subjacent to diluvium, between Prome and Ava, remarks on, 385 *et seq.*

C.

Caithness, schist of, compared with those of Thuringia, 315.
——— Ord of, altered limestone of the oolitic series at, 307.
——— breccia of the oolitic series in contact with granite at, 306.
Calabrian coast elevated, and contains Lithophagi, 351.
Calcareous strata, contortions of, at Darlstone Bay, 37.
——— spar in the lias formation at Lyme Regis, 29.
Caldcleugh, Alexander, Esq., on the geology of Rio de Janeiro, 68.
Camaldoli della Torre, built on the side of Somma, 339.
——— convent of, description of the summit of the hill on which it stands, 347, 348.
Campania, plains of, raised by subterraneous expansion, 352.
Canal in the peat of Loch Kinnordy, 87 *note.*
Capo di Chino, structure of, described, 350.
——— Miseno, described, 343, 344.
——— Monte, structure of, described, 350.
Capomazza, described, 343, 346.
Carabari, fossils from, 393.
——— deposits of, described by Mr. Colebrooke, 394.
Cardium dissimile, new species, Brora, formerly called Venus of Portland, 318.
——— striatulum, new species, Brora, 320. 366.
Carsaig, Mull, altered rocks of oolitic series at, 359.
——— south coast of Mull, fossils of lias at, 311.
Caserta valley, structure of, 351.
Castle hill, Caithness, slate quarries of, 314.
Cavities under volcanoes disallowed, 345.
Cephalopoda, arrangement of, 67.
Chambered Univalves in the lias formation at Lyme Regis, 27.
——— in the chalk near Lyme Regis, 111.
Chara, on the, and its seed-vessel the gyrogonite, 90.
——— species of, 92.
Chelonia, fossil species of, found in the Irawadi, 374.
Clay and sands, junction of, with the Purbeck limestone-beds, 39.
——— in the lower part of the strata at Hastings, 31.
——— blue marly, found near Wetmasut, 383.
Clift, William, Esq., on the fossil remains of two new species of Mastodon, and other vertebrated animals, found on the left bank of the Irawadi, 369.
Clinkstone, changed into pitchstone, 344.
Clyne, hills of, composed of red conglomerate, 294.
——— junction of granite, with strata of Brora coal-field at, 295.
Coal-measures of the western extremity of the Great South Welsh coal-basin, 17.
——— remarkable contortions of, especially at Monk's Stone Point, 18.
——— stone or culm, the only variety in Pembrokeshire, 18.
——— bituminous, altogether wanting in Pembrokeshire, 18.
Colliery at Begelly, section of, 19.
Conglomerate, calcareo-siliceous, found near Wetmasut, 383.
Cone, volcanic, characteristic of a, 350.
——— at Cumæ, 349.
Conites Bucklandii found at Stonesfield, 400.
Cooch-behar, animal remains found at, 393.
Corals in the limestone of Southern Pembrokeshire, 16.
——— casts of, in the lias of Lyme Regis, 29.
Corbula, new species undescribed, Brora, 320.
Crachaig Point, Brora, sandstone of, 305.
Craters in the island of Procida, 349.
Crawfurd, J. Esq., geological account of rocks,

and a series of animal and vegetable remains, collected by, on a voyage up the Irawadi to Ava, 377.
Crinoidea in the lias formation at Lyme Regis, 29.
Crocodilidæ, fossil remains of, found in the Irawadi, 375.
Crocodilus vulgaris, fossil remains of, in the Irawadi, 375.
Cromarty, east coast of, 307.
Crustacea in the lias formation at Lyme Regis, 27.
——— in the sand and sandstones beneath the chalk near Lyme Regis, 113.
Cucullæa, two new species of, undescribed, Brora, 320.
Culley, Matthew, Esq., his notice of the Banniskirk fossil fish, 314.
Culm: *see* Coal.
Cumæ, acropolis of, noticed, 349.
Cuvier, Baron, on fossil remains of a new gigantic Saurian from Headfold-wood Common, 104.
——— fossil fish of Caithness referred to, 314.
Cuvier and Brongniart, shells of the upper marine formation in the Paris basin, described by, 394.
Cycadeoidea megalophylla, 397.
——— microphylla, 398.
——— leaves nearly allied to, found near Whitby, 399.
——— engraved by Bird and Long, 399.
——— in the possession of Mr. Featherstonhaugh, 399.
Cycadeoideæ, on the, from the oolitic quarries of Portland, 395.
——— stems of, only found in Portland stone, 399.
Cycas, recent, analogies between, and a new species of fossil plant, 396 *et seq.*
——— five known species of, 396 *note.*
——— revoluta, described by Sir J. Smith, 398.
——— circinalis described in *Hortus Malabaricus*, 399.
Cyclas, five species of, Loch Staffin, Skye, of which two are new, 366.
Cypris faba in Petworth marble, 103.
Cyrena, species of, found near Wetmasut, 383, 386.

D.

Darlstone Bay, contortions of calcareous strata at, 37.
Deer, fossil remains of, found in the Irawadi, 374.
—— bones of, enumerated, 379, 380.
De la Beche, H. T. Esq., on the geology of Southern Pembrokeshire, 1.
——— on the lias of the coast in the vicinity of Lyme Regis, Dorset, 21.
——— on the chalk and sands beneath it (usually termed green-sand) in the vicinity of Lyme Regis, Dorset; and Beer, Devon, 107.
——— on the geology of Jamaica, 144.
Denudation of Braambury and Hare hills, Sutherland, 357.
Diluvial accumulations of chalk flints at Rogate Common, 102.
——— not found on the subjacent Weald clay, 102.
——— deposits of the Hampshire basin, 128.
——— near Newbury, contain the remains of elephant, rhinoceros, &c., 128.
——— plain of Liguanea, Jamaica, 184.
Diluvium and alluvium, Jamaica, 182.
——— of Strathmore, 74.
Druson Haven: *see* Trap.
Dunnet-head, Caithness, red sandstone of, compared with new red sandstone of England, 314.
Dunrobin Castle, organic remains in the beds exposed on the shore at, 302.
Dykes of trap, enveloping Gryphites and other shells, 359.
———vertical basaltic, seen at Atrio del Cavallo, 339.

E.

Eastern Moorlands, comparison of, with Brora, 293.
Echini, rare, in the lias formation at Lyme Regis, 28.
Echinites in the chalk near Lyme Regis, 111.
——— in the sands and sandstones beneath the chalk near Lyme Regis, 114.
——— in the yellowish white Jamaica limestone, 169.
——— of the Jamaica white limestone formation, 170.
Echino-spatagus in the Malm-rock, 99.
Edlw-y-seg, rocks of, part of the edge of the great coal-basin of North Wales, 238.
Elephant, bones of, supposed to have been found in London clay at Brentford, 390.
Elevation of the western coast of Italy, remarks on, 351.
——— granite in solid form, 354.
Emys, fossil remains of, found near the Irawadi, 375.
——— bones of, enumerated, 379, 380.
Encrini in the limestone of Southern Pembrokeshire, 16.
Encrinite in the chalk near Lyme Regis, 111.
Epomeo Monte, craters of, described, 343.
Equisetum columnare of M. Adolphe Brongniart, recognized as identical with Oncylogonatum carbonarium, Brora, 368.
Ethie, Rosshire, sandstone of, 308.
Euomphali in the limestone of Southern Pembrokeshire, 16.

F.

Faraday, Michael, Esq., his examination of different specimens of marl, limestone, &c., with a view to ascertain whether they afforded traces of animal matter, 95.
Feldspar, glassy crystals of, in the lavas of Ischia, 342.
——— trachyte of the Solfatara, 345.
Femur, fossil, of a new gigantic species of Saurian, at Headfold-wood Common and Loxwood, 104.
Ferns, impressions of, in the sands and sandstones beneath the chalk near Lyme Regis, 112.
Firestone or upper green-sand (Malm-rock of Hants and Sussex), 98.
Firestone, depth of wells sunk in, 99.
——— fossil fish, testacea, and echinodermata in, 99.
Fish, fossil, in the lias formation of Lyme Regis, 27.
——— in the slate of Banniskirk, Caithness, 314.
——— tooth of a, and dorsal fin of a, in the East Cliff, Hastings, 35.
——— scales of, highly polished, in the East Cliff at Hastings, 35.
——— palates and teeth of, in the chalk near Lyme Regis, 111.
Fitton, Dr., Strobilus found by, 396 *note*.
Forest, submarine, at Hastings, 35.
Formations recognised between Prome and Ava, 386 *et seq.*
Fossil fish: *see* Banniskirk, Gamrie.
——— organic remains in the formations of the oolitic series at Brora and in the Hebrides, 318.
——— shells at Loch Staffin, Skye, described, 358.
Freshwater formation near Wetmasut on the Irawadi, described, 387.
Furrows and parallel scratches on surface of rock, Brora, 357.

G.

Gamrie, near Troup Head, Banff, locality of fossil fish, 363.
Gault, at Bentley, Binsted, and the forest of Alice Holt, 100.
——— Ammonites dentatus frequent in, 100.
Gavial, fossil remains of, in the Irawadi district, 379, 380.
Glassy feldspar in the Monte di Procida, 349.
Gneiss of Rio de Janeiro, leading direction of, 70.
——— of Sutors of Cromarty, 355.
——— no ores of consequence discovered in, 71.
——— siliceous stalactites in, 72.
——— simple minerals in, 71.

Gordon, Alexander, Esq., on three forests of fir imbedded in peat, 140.
Granite not in fluid state when upheaved on coast of Sutherland, 356.
——— in trachytic conglomerate, 349.
——— of Ord of Caithness, 353.
Grauwacke found in Manlan Hill, near Wetmasut, 388.
——— of North Pembrokeshire, its southern boundary line, 8.
——— district of St. David's, 9.
——— Haverfordwest, 9.
——— south of the coal-basin in Pembrokeshire, 10.
——— Jamaica, 149.
Gravel, diluvial, (Liguanea, Jamaica,) 184.
Graystone of the Ponza Isles, 214.
Gray wethers near Hungerford, 126.
——— co-extensive with the entire surface of the chalk in more or less abundance, 126.
Green-sand, lower, of N. W. of Sussex, &c. supports a number of lakes and ponds, 102.
——— of Lyme Regis and Beer, 108.
——— of the vale of Kingsclere, 121.
——— on the summits of the Savoy Alps, 127.
Grey, Sir George, fossil plant in the possession of, 395.
Gryphæa Maccullochii, new species, Pabba, Skye, Mull, &c., 322.
Gyrogonite, seed-vessel of Chara, 90.
——— of the Bakie, 91.
——— new species of, Chara tuberculata, (fossil), 94.

II.

Harting Combe, Weald-clay in, nucleus of the district described in the memoir on the N.W. of Sussex &c., 97.
Hastings, strata of, 30.
——— cliffs of, not rich in organic remains, 30.
Haverfordwest: *see* Grauwacke.
Hawkley Slip, 100.
Hazel nuts, great quantities of, among the trunks of trees on the shore at Hastings, 35.
Helmsdale, Sutherland, shelly limestone of, burnt for use, 305.
Henley, H. H. Esq., collection of fossil plants of, 395.
Hippopotamus, bones of, in the valley of the Irawadi, 379.
——— fossil remains of, found in the Irawadi, 373.
Hog, bones of, in the valley of the Irawadi, 379.
Holm, Skye, cliff and fossils of inferior oolite at, 310.
Hornblende found near Ava, 389.
Hyæna, bones of, supposed to have been found at Brentford, in London clay, 390.
Hypothesis, accounting for the creation of volcanic mountains, 340, 341.

I. J.

Jamaica, H.T. De la Beche, Esq., on the geology of, 143.
——— rocks, comparison of with those resembling them in Mexico and South America, 190.
Jameson, Professor, his description of the granite of the Ord of Caithness, 353 *note*.
Ichthyolites of Gamrie described, 364.
Inimore of Carsaig, trap rocks of, 312.
Irawadi, supposed power of petrifying wood possessed by the waters of, 403.
——— bed of the river, thickly set with wooden piles between Rangoon and Ava, 403.
——— fossil remains of two new species of Mastodon and other vertebrated animals, found on the left bank of the, 369.
Iron, hydrate of, in bones from Ava, 381.
——sand, formation of, Sussex, Gideon Mantell, Esq., on the, 131.
——— of the vale of Sussex, 103, 131.
——— quantity of calcareous matter in, 107.
——— remains of vegetables in, 134.
——— vertebrata in, 104, 134.
——works ancient in the Weald-clay, 103.
Ischia, a principal volcanic vent, 338.
——— form and structure of the mountain, 342.

Ischia, lavas of, described, 341, 342.
Italy, western coast of, elevated, 351.

K.

Kilmot, Sutherland, shelly limestone of, 305.
Kingsclere, Professor Buckland on the formation of the valley of, &c., 119.
Kintradwell, Brora, reefs at, 304.
König, Charles, Esq., his description of a fossil vegetable in the coal field of Brora, 298.

L.

La Gabbia, islet of, 198.
Lago d'Agagno described, 347.
—— d'Averno, hills surrounding, described, 343, 347.
—— di Ronciglione described, 347.
Lake Aral, marine deposits near, 394.
Lava beneath Solfatara, intensely heated, 344.
—— del Arso described, 343.
—— of Monte Olibano, 346.
—— trachytic, near Pianura, used in building, 348.
———— in island of Procida, 350.
———— occurs at Rocca-Monfina, St. Agata, and Sorrento, 348.
Lavas of Ischia described, 342.
Leptorhynchus, fossil remains of, in the Irawadi, 375.
Lias, faults observable in, at Lyme Regis, 25.
—— organic remains of, at Lyme Regis, 27.
—— limestone, characteristic testacea of, by no means uncommon at Lyme Regis, 26.
—— section of, near Seven-rock Point, 24.
—— section of upper marl beds of, at the base of Black Ven, 23.
Lignite found near the town of Wetmasut, Irawadi, 378.
———— in oolite of Mull, 312.
Liguanea, diluvial plain of, 184.
Lime, carbonate of, in bones from Ava, 381.
Limestone, altered, of the oolitic series at the Ord of Caithness, 307.
———— band of Tenby, 14.
———— —— Pembroke, 15.
———— St. Goven's, 16.
———— carboniferous, to the north and south of the Pembrokeshire coal-basin, 14.
———— discovered near Robagiri, 387.
———— Silhet, 387.
———— found near Wetmasut, 388.
———— at Robagiri, 387.
———— in hills opposite Prome, 383.
———— of Bakie, comparison of, with other freshwater limestones, 83.
———— series of Purbeck, section of, 38.
———— transition, associated with grauwacke at Manlan Hill near Wetmasut, 388.
———— tufaceous, on the origin of, 81.
———— white formation, Jamaica, 169.
Lithophagi in the limestone cliffs of Monte Circello and the Calabrian coast, 351.
Loch Sligachan, lias fossils at, 311.
—— Staffin, Skye, freshwater formation, 358.
Loddiges, William and George, Esqrs., examination of new fossil plants by, 396.
London clay and calcaire grossier formation in the district of the Irawadi, described, 386.
Loth, vale of, 304.
Lower green-sand in the N.W. extremity of Sussex, and adjoining parts of Hants and Surrey, dip of, 101.
———— depth of wells in, 102.
———— diluvial accumulations of chalk-flints on the surface of, 102.
———— passage from, to the Weald-clay, 102.
Luidas Vale, Jamaica, cavern at, 185.
Lyell, C. Esq., on a recent formation of freshwater limestone in Forfarshire; and on some recent deposits of freshwater marl; with a comparison of recent with ancient freshwater formations; and an appendix on the Gyrogonite or seed-vessel of the Chara, 73.
———— his visit to Brora, 293.
Lyme Regis, remains of fish, testacea, &c., in chalk, near, 110.

M.

Macculloch, J., M. D., his account of lignite and coal referred to, 301.
——— his "Western Islands" referred to, 309.
Maddeloni valley, structure of, 351.
Madras, tertiary deposit of, noticed, 387, 394.
Malachite, small portions of, in the quartz of Lawley Hill, and Caer Caradoc, 248.
Malm-rock, organic remains in, at Nursted and Buriton, 99.
——— quantity of calcareous matter in, 107.
Mammalia, extinct race of, discovered in Bengal, 393.
Manlan-hill, near Wetmasut, composed of grauwacke and transition limestone, 388.
Mantell, Gideon, Esq., on the iron-sand formation of Sussex, 131.
Mantle-form stratification characterized, 350.
Marble, Purbeck, 40.
——— univalves in, 40.
——— statuary, found near Ava, employed for making images, 389.
Marine deposits near Lake Aral, 394.
——— on the shores of the Mediterranean, 394.
Marl near Romsey, Hants, bones of stag, roebuck, beaver, pig and ox, in, 89.
——— section of, in Ashley Meads, 88.
—— limestone, &c., Mr. Faraday's examination of, with a view to animal matter, 95.
—— of Bakie Loch, organic remains of crustacea and testacea in, 78.
——— plants in, 79.
——— quadrupeds in, 77.
—— of the Loch of Kinnordy, 86.
—— plants in, 89.
—— rock, on the origin of, 81.
—— scales of mica frequent in, 87.
—— section of, 75.
—— seed-vessels of Charæ in, 87.
Marl shell, on the origin of, 79.
—— skeleton of Cervus Elaphus in, 87.
—— testacea in, 89.
—— beds at Benham Marsh, 130.
——— lower, of the lias at Culverhole Point, their section, 26.
——— their fossils, 22.
——— upper, of the lias at Black Ven, their section, 23.
Marloes: *see* Trap.
Marshall, W. Esq., on carbonate of copper in the magnesian limestone at Newton Kyme, 140.
Mastodon, bones of, in the valley of the Irawadi, 379, 380.
——— elephantoides, bones of, noticed, 380.
——— description of, 372.
——— fossil remains of, found in Asia, 370.
——— the Ohio, 370.
——— found near the Irawadi, description of two new species of, 369.
——— giganteum compared with M. latidens, 371.
——— latidens, description of, 371.
——— teeth of, characteristic of species, 370 *et seq.*
——— teeth of, in British Museum, 372.
Medial or carboniferous rocks, Jamaica, 157.
Mica, considerable quantity of, in the upper strata of the upper lias marls of Lyme Regis, 22.
—— scales of, frequent in the marl of Loch Kinnordy, 87.
—— slate found near Ava, 389.
Micaceous slate and hornstone, Jamaica, 154.
Miller, Mr. J. S., on Belemnites, 45.
——— the genus Actinocomax, 63.
Misenum, promontory of, described, 350.
Modiola, new species, Brora, 366.
Mollusca, multitudes of shells of freshwater, in the strand of the Kennet Peat, 129.
Monk's Stone Point: *see* Coal-measures.
Montagna della Guardia, 199.
Montagnone, cone of, noticed, 342.
Monte Barbaro described, 343, 346, 347.
——— Circello, limestone cliffs of, elevated, 351.
——— Epomeo, craters of, described, 343.

Monte Nuovo, described, 344.
——— of the Lucrine Lake, structure of, 351.
—— Olibano, summit of, described, 346, 347.
—— di Procida described, 349.
——— Tabor, trachytic hummock noticed, 342.
Mull, inferior oolite and lias on south coast of, 311.
Murchison, R. I., Esq., on the coal-field of Brora, Sutherland, and the oolitic series of the Hebrides, 293.
——— on the north-western extremity of Sussex, and the adjoining parts of Hants and Surrey, 97.
——— supplementary remarks on the oolitic series in the north of Scotland, 353.

N.

Naples, description of the interval between the extremes of the volcanic district of, 343 *et seq.*
——— extent of the volcanic district of, defined, 337.
Navidale, valley of, and its structure, 306.
Nerita, not figured, Loch Staffin, Skye, 366.
New red sandstone, section of upper part of, at Axmouth Point, 29.
Nisida, island of, described, 343, 344.
——— structure of, described, 350.
Nucula, unfigured, Western Islands, 367.
——— new species, Brora, 366.
Nummulites in tertiary deposits of Silhet, 394.
Nuts, hazel, in great quantities among the trunks of trees on the shore at Hastings, 35.

O.

Obsidian near the Punto di Campanella, 352.
Oernant Mountain, slate quarry of, 238.
Old red conglomerate elevated on the peaks of granitic mountains, Sutherland, 356.
——— sandstone to the north of the Pembrokeshire coal-basin, 11.
——— south of ditto, 11.
Old red sandstone of the Milford subdivision, 12.
——— Pembroke ditto, 12.
——— Orielton ditto, 13.
——— Strathmore, 74.
——— Jamaica, lower beds of, graduate sometimes into the grauwacke, 161.
Old salt-pans, Brora, fossils of, 303.
Oncylogonatum carbonarium, fossil vegetable, Brora, described by Charles König, Esq., 300.
Oolitic lias, Applecross and Cowbridge, 362.
——— series in the Hebrides, Sutherland and Ross, supplementary remarks on, 353.
——— of Scotland identified with that of England, 313.
Ord of Caithness, granite composing it, described, 294.
——— again described, 353.
Organic remains of the Jamaica white limestone formation, 170.
——— at Kintbury, 120.
Ostreæ in the yellowish white Jamaica limestone, 169.
——— in the plastic clay formation at Kintbury, 120.
Ox, bones of, enumerated, 379, 380.
—— fossil remains of, found in the Irawadi, 374.

P.

Pabba, isle of, cited as composed of upper lias shale, 363.
——— lias fossils of, 322.
Pachydermata, bones of a herbivorous animal from Bengal referrible to the order of, 393.
——— bones and teeth of, in the valley of the Irawadi, 379.
——— fossil species found on the left bank of the Irawadi, 369.
Palmarola, islet of, 215.
Paludina, not figured, Loch Staffin, Skye, 366.
Paludinæ ? in the calciferous sandstone and sandstone not calciferous at Hastings, 35.
Pausilipo, promontory of, structure described, 350.

Peat of Loch Kinnordy, canoe in, 87 *note*.
—— of the valley of the Kennet, 128.
Pecten orbicularis, characteristic fossil of the Malm-rock, 99.
——— three new species of, in lias of Carsaig, Mull and Pabba, 367.
——— five species of, at Brora, of which two are new, 365, 366.
Pembroke: *see* Coal, Culm, De la Beche, Grauwacke, Limestone, Old red sandstone, Trap.
Pentamerus, casts of, at Norbury quarry, 244.
———— Knightii, detailed description of, 247.
Pentland, J. B. Esq., on some fossil remains from Bengal, 393.
———————— his description of the Ichthyolites of Gamrie, 364.
Persoon, M., on Cycadeæ, noticed, 396.
Petrolean wells found on the shores of the Irawadi, near Wetmasut, 378, 381, 386, 388 *note*.
Pianura, feldspathose rock, compared with that of Rocca-Monfina, &c., 348.
Piperno used in building at Naples, 348.
Pisolites, formation of, 346.
Pitchstone passage into pumice, 344.
———— green and yellow, at the junction of the prismatic trachyte and semivitreous conglomerate, Ponza, 206.
———— in the Monte di Procida, 349.
————in trap dykes traversing lias and inferior and middle oolite, 359.
Plagiostoma, three species, Pabba, of which one species is new, 368.
Plants, fossil, from Isle of Portland, described by Dr. Buckland, 395 *et seq.*
—— (fuci ?) impression of, in the slate clay at Leach Heath, 256.
—— monocotyledonous, portions of silicified stems of, in the lower beds of sandstone and shaly clay at Hastings, 35.
Plastic clay formation of the Irawadi district, 388.
Pondicherry, tertiary deposits and silicified wood found at, 394.
Ponza group, connection of the, with congenerous formations of the Italian coast, 232.
———— geological description of, 197.
——— Isles, analogy between the volcanic formations of, and those of other countries, 225.
———— G. Poulett Scrope, Esq. on the geology of, 195.
Porphyritic conglomerate, Jamaica, 163.
Portgower, Sutherland, remarkable dislocations at, with breccia of limestone and shale in contact with granite, 305.
Portland cave, Jamaica, 185.
Port Royal mountains, Jamaica, red sandstone and conglomerate among, 163.
Portree, Skye, trap rocks at, 310.
Post-diluvian formations of the valley of the Kennet, 128.
Primitive rocks of Irawadi district, 389.
Prince's Cave, section of cliffs near, 360.
Prismatic trachyte, change observable at its point of contact with the semivitreous trachytic conglomerate, Ponza, 204.
Procida, western point of, described, 343.
Producti in the limestone of the Pembroke band, 16.
Prome, pillars of a house at, petrified, 391.
———————— teak supposed to be silicified under a building near, 403.
——— sandstone found near, 388.
——— sandy limestone, 386.
Pugan, sandstone found near, 388.
——— slaty limestone, 386.
Pullastra, new genus, Brora and Yorkshire, 298.
Puntò di Campanella, sandstone and tufa near the, 352.
Purbeck beds contain marine and freshwater shells, 40.
———— fossil fish and turtles in, 40.
———— junction of, with the Portland beds, 41.
——— limestone series, section of, 38.
Pyrites, iron, in the lias formation of Lyme Regis, 29.

R.

Red conglomerate of Sutherland and Ross, 313.
— marl-beds, thickness of, between Culverhole and Axmouth Points, 29.
— sandstone and conglomerate, Jamaica, 161.
———— old : *see* Old red sandstone.
Remains, organic, of the chalk near Lyme Regis, 110 *et seq.*
Reptilia, fossil species of, found in the Irawadi, 374.
Rhinoceros, bones of, in the valley of the Irawadi, 373, 379.
Robagiri, near, is a stratum of white limestone, 387.
Rocca-Monfina, trachytic lava a produce of the volcano of, 348.
Roche : *see* Trap.
Rock, mamillated, at Hastings, 32.
Ross, east coast of, 307.
Rother river rises in chalk, and after flowing through it, the Malm-rock and the Gault, confined to the lower green sand, 102.
Round Hill in Vere, Jamaica, warm saline spring from the limestone at its base, 173.
Ruminant, bones of a, from Bengal, 393.
Ruminantia, bones of, in the valley of the Irawadi, 379, 380.
———— fossil species of, found in the Irawadi, 374.

S.

Sands and sandstones beneath the chalk at Branscombe and the Beer quarries, 116.
———— beneath the chalk near Lyme Regis, 112.
———— beneath the chalk at White Cliff, Beer, 115.
Sandstone beds, Jamaica, closely resembling some English coal-measures, 159.
———— blocks of, coextensive with the chalk in more or less abundance, 126.
———— sometimes drifted beyond the present area of the chalk, 127.
———— and conglomerate next to the white limestone, Jamaica, 182.
Sandstone, ferruginous, of Hastings, 31.
———— found near the Irawadi, 384, 388.
———— hard, grey, calciferous, of Hastings, 31.
———— casts of a small bivalve therein, 35.
———— yellow, soft, friable, of Hastings, 31.
San Stefano, islet of, 224.
Sauria, fossil species of, found in the Irawadi, 375.
Saurians, fragments of ribs of, in the East Cliff at Hastings, 35.
———— in the lias formations in the vicinity of Lyme Regis, 27.
———— remains of new gigantic species of, at Headfold-wood Common, &c., 104.
Savannah conglomerate and sandstone, Clarendon, Jamaica, 182.
Scoglio della Botte, insular rock, 221.
———— delle pietre arse, composed of pitchstone, 349 *note*.
Sconser, lias limestone of, 311.
Scrope, G. P. Esq., on the volcanic district of Naples, 337.
Sedgwick, Professor, cited as authority, 353.
———— his sketch of the Yorkshire coast, 293 *note*.
———— visit to Brora and the Hebrides with Mr. Murchison, 353.
Seeds and nuts in the Kennet peat, 128.
Selborne, formation of Malm-rock or firestone well seen at, 98.
Selenite in the lias formation of Lyme Regis, 29.
Semivitreous trachytic conglomerate, Ponza, 203.
Septaria of Lyme Regis frequently contain ammonites in their centre, 29.
———— sometimes entirely without organic remains, 29.
———— not uncommon in the lias marls of Lyme Regis, 29.
Shale beds, black, bituminous, testaceous matter well preserved in, 238.
—— of the inferior oolite, 361.
—— in the lower part of the strata at Hastings, 31.
Shark's teeth in the plastic clay formation at Kintbury, 120.

Shells, fossil, found near the town of Wetmasut, 378, 386.
——————— at Pugan district, 386, 387.
——— freshwater? in the calciferous sandstone at Hastings, 35.
——— marine, in tertiary deposits of Asia, 394.
Shiant Isles, extension of lias to, 312.
Sidmouth, blocks of sandstone at, a siliceous breccia of the same age and character as the Hertfordshire pudding-stone, 127 *note*.
Sienite in trachytic conglomerate, 349.
Silhet, Laour hills near, composed of white limestone containing Nummulites and vertebræ of fish, 387.
——— tertiary deposits near, 394.
Siliceous trachyte, Ponza, 208.
Skomer island: *see* Grauwacke, Trap.
Skull, a human, found in the valley of the Kennet, at the contact of the peat with the shell marl, 128.
Slate quarry of the Oernant mountain, 238.
Smith, Sir James, description of the Cycas revoluta noticed by, 398.
——— William, Esq., his section of the Yorkshire coast, 297.
Sofatara of the volcanic district of Naples, described, 343.
——————————————— globular concretions formed in the, 346.
——————— eruption of, 346.
Somma, a principal volcanic vent, 338.
——— crater of, when formed, 339.
——— described, 338, 339, 340, 341.
——— eruptions of, described, 339.
Sorrento, trachytic lava in volcano of, 348.
——————— volcanic formations at, 352.
South-downs, chalk escarpments of, 97.
Southern Pembrokeshire: *see* De la Beche, and Trap.
Sowerby, Mr., fossil plants in the museum of, 395.
Spar, calcareous, in the lias formation of Lyme Regis, 29.
St. David's: *see* Trap.
St. Goven's: *see* Limestone.
Stammerham quarry, section of, 133.
Sternberg, Count, description of a fossil amentum by, 400.
Stone-coal: *see* Coal.
Stone, rude instruments of, accompanying a human skull found at the contact of the Kennet peat with a substratum of shell marl, 128.
Stonesfield, oolitic slate, contains leaves resembling the Cycadeæ, 400.
Strata, order of superposition of, in the N.W. of Sussex and adjoining parts of Hants and Surrey, commencing below the chalk, 106.
——— tertiary, of the district of the Irawadi, 384, 385.
——————— near Madras, 387.
Strathsteven, sandstone quarries of, 303.
Streatham Common, section of a well sunk at, 135.
Strobilus discovered by Dr. Fitton, 396 *note*.
Submedial or transition rocks, Jamaica, 148.
Sulphate of alumine, at Solfatara, 345.
——— of barytes in the lias formation of Lyme Regis, 29.
——— iron ditto ditto, 345.
——————— lime ditto ditto, 345.
——————— magnesia ditto ditto, 345.
——— soda ditto ditto, 345.
Sulphuric acid formed at Solfatara, 344.
Superior or tertiary rocks, Jamaica, 169.
Supermedial or secondary rocks, Jamaica, 163.
Sus, fossil remains of, found in the Irawadi, 373.
Sutors of Cromarty, lias and fossils of, 308, 309.
——————————— structure of, 355.

T.

Table of fossil shells in the district of Brora and the Western Islands, 318.
Tapir, bones of, in the valley of the Irawadi, 379.
——— fossil remains of, found in the Irawadi, 374.
Teeth, fossil, analogous to those of the Lizard tribe in the East Cliff, Hastings, 35.
Tenby: *see* Limestone.
Teneriffe, notice of the fissures on the sides of the mountain, 341.

Terebratula, 3 species, Hebrides, of which one is new, 368.
Terra di Lavoro, structure of, 351.
Tertiary formations exist near Madras, 387.
——— existence of, traced in Africa, 388.
——— Asia, 388.
——— throughout Europe, 388.
——— marine deposits in Bengal, 393.
——— strata of the London and Hampshire basins, evidence of original continuity of, 126.
——— not limited in their extent to certain hollows within the area of the chalk, 128.
——— on the summits of the Savoy Alps, 127.
——— traced along the shores, and in the islands of the Mediterranean, 388.
Testaceous matter well preserved in bed of black bituminous shale, 238.
——— mollusca in the lias formation at Lyme Regis, 27.
Thibetian mountains, tertiary deposits at the base of, 394.
Tilgate forest, strata and organic remains of, 131.
Tobermory, Mull, locality of oolitic series, 361.
Tooth, fossil, of a fish in the East Cliff, Hastings, 35.
Torre del Greco, volcanic cones above, 339.
Tortoise, vertebra of? in Stammerham quarries, 104.
——— freshwater, fossil remains of, in the valley of the Irawadi, 379, 380.
——— in the Hastings and Purbeck limestone, 381.
——— Kimmeridge clay, 381.
——— lias of Gloucestershire, 381.
——— London and plastic clay, 381.
——— Stonesfield oolite, 381.
——— tertiary sand rock of Brussels, 381.
——— transition slate of Glarus, 381.
Trachyte, earthy, regular and constant columnar division of, Ponza, 228.
——— in rock of the Acropolis of Cumæ, 349.
——— Lacco in Ischia, 349.
——— of the Ponza Isles, 199 *note*.
——— Ponza, ribboned structure of the, 225, 228.
——— prismatic, Ponza, 200.
——— produced by the Salfatara, described, 345.
——— contains augite, 213.
——— siliceous, Ponza, 206.
——— varieties of, in the lavas of Ischia, 342.
Trachytes, the, with their conglomerates, separated from the graystone by horizontal strata of tufa, Ponza, 225.
Trachytes and conglomerates, conversion of, into pitchstone, Ponza, 228.
Trachytic conglomerate, change observable in, at its point of contact with prismatic trachyte, Ponza, 204.
——— of the Monte di Procida described, 349.
——— semivitreous, Ponza, 203.
——— used as a building stone, 343.
——— description of, 343.
Trafgarn: *see* Trap.
Transition limestone, Jamaica, 151.
——— rocks, Jamaica, 148.
——— series of the Irawadi district, 388.
Trap, between Druson-haven and Broad-haven, 6.
—— dyke, remarkable, near Bewdley, 249.
—— from Bolton Beacon to Benton Castle, 7.
—— insulated masses of, in the vicinity of St. David's, 4.
—— in the range from Roche to Trafgarn, 6.
—— of Gouldtrop Road in St. Bride's Bay, 6.
—— Marloes and Skomer Island, 8.
—— rocks associated with the submedial rocks, Jamaica, 155.
—— varieties of, in southern Pembrokeshire, 2.
—— of the Rhine compared, 342, 351.

Trees, branches and other remains of, in the Kennet peat, 128.
—— dicotyledonous fossil, in the Portland and Purbeck beds, 41.
—— trunks of, between White Rock and the West Cliff, Hastings, 35.
Trigonia, new species, Western Islands, 367.
Trionyx, bones of, enumerated, 379, 380.
———— fossil remains of, found in the Irawadi, 374.
Trotternish, Skye, highest members of the oolitic series, 363.
Tufa, horizontal strata of, separating the trachytes with their conglomerates from the graystone, Ponza, 225.
—— near the Punto di Campanella, 352.
———— Naples, 350.
—— solid in the promontory of Pausilipo, &c. 350.
Tufas of Ischia described, 342.
——— Monte Nuovo, 351.
——— Sorrento, 352.
——— Vico, 352.

U.

Univalves, chambered, in the lias formation at Lyme Regis, 27.
———————— of the Malm-rock, 99.
———————— in the chalk near Lyme Regis, 112.
———————— sands and sandstones beneath the chalk near Lyme Regis, 114.
———— not chambered in the chalk, 112.
———————————— sands and sandstones beneath the chalk near Lyme Regis, 114.
———————————————— lias formation at Lyme Regis, 28.
———— irregular in the lias formation at Lyme Regis, 28.
———— multilocular, of the Jamaica white limestone formation, 170.
———— not chambered, of the same, 170.
Uppat, hills of, composed of red conglomerate, 294.
Upper greensand or firestone of Hants &c., depth of, 99.
——— marine and lower freshwater formations, junction of the horizontal strata of, 94 *note*.

V.

Valleys of elevation, 123.
Vegetable matter and wood abundant in the blacker beds of clay at Kintbury, 120.
———— remains in the lias formation of Lyme Regis, 29.
Vegetables, fragments of, carbonized in the lower parts of the strata at Hastings, 31.
Ventotiene, island of, 221.
Vertebræ, fossil, of new gigantic Saurian, 104.
Vesuvius, a principal volcanic vent, 338.
———— cone of, when formed, 339.
———— crater of, 339.
———— eruptions of, described, 339, 340.
———— mountain of, described, 340, 341.
Vico, volcanic formations at, 352.
Viverra, bones of a carnivorous animal from Bengal, of the genus, 393.
Viviparæ in the Weald clay, 103.
Volcanic formations shown at Vico and Sorrento, 352.
———— rocks at Black Hill, Jamaica, 186.
———— vents parallel to the nearest linear elevation of strata, 337.
Vomero, hill of, structure noticed, 350.

W.

Wallich, Dr., his opinions and remarks on the supposed power of the waters of the Irawadi to convert wood into stone, 403.
Weald clay, ancient iron-works in, 103.
———— Cypris Faba in, 103.
———— at Harting Combe, nucleus of Western part of the district, 102.
———— passage from the lower green-sand to, 102.
———— viviparæ in, 103.
Webster, Thomas, Esq., fossil plant presented to the Geological Society by, 395.

Webster, Thos. Esq., on the Purbeck and Portland beds, 37.

——————————— strata at Hastings in Sussex, 31.

Western Islands, oolitic series of, 310.

Wetmasut on the Irawadi, district of, composed of sandhills, 378, 382.

——— selenites and petroleum wells found near, 381, 388.

Wey river rises in the chalk, and after flowing through it, the Malm-rock and the gault successively, has its course for twenty miles in the lower green-sand, 102.

White limestone formation of Jamaica characterized by holes and caverns in which the waters of the district are lost, 176.

Wood abundant in the blacker beds of clay at Kintbury, 120.

——— fossil, in the Irawadi district, 378, 382, 384.

Wood silicified, at Pondicherry, 394.

Wren's Nest, section of the, 251.

Y.

Yates, Rev. James, on the quartz rock of Bromsgrove Lickie, 137.

——————————— structure of the border country of Salop and North Wales, &c., 237.

Yorkshire, coast of, fossils of calcareous grit, compared with those of Braambury, Brora, 297.

——————————— the pier stone, Scarborough, compared with those of roof of coal, Brora, 298.

Z.

Zamia, recent, analogies between, and a new species of fossil plant, 396 *et seq.*

Zannone, island of, 198, 219.

A LIST OF DONATIONS

TO THE LIBRARY,

TO THE

COLLECTION OF MAPS, PLANS, SECTIONS, AND MODELS;

AND TO

THE CABINET OF MINERALS,

BELONGING TO

THE GEOLOGICAL SOCIETY,

From the Close of the Sixteenth Session in June 1823, *to the Close of the Twenty-second Session in June* 1829.

TOGETHER WITH THE DATES AT WHICH THEY WERE RESPECTIVELY MADE,

AND

THE NAMES OF THE DONORS.

1. *Donations to the Library.*

1823.	BOOKS.	DONORS.
June 28.	On the Stratification of Alluvial Deposits and the Crystallization of Calcareous Deposits, by H. R. Oswald, Esq.	The Author.
	Quarterly Journal of Science, Literature and the Arts, Nos. 30—32.	Royal Institution.
1824.		
Jan. 2.	Report on the Roads and Mines of the Estates of Greenwich Hospital, by E. H. Locker, Esq.	The Author.
14.	Lettre de M. Léopold de Buch à M. de Humboldt, renfermant le Tableau Géologique du Tyrol Méridional.	The Author.
21.	Report on the Proceedings for destroying the Smoke from smelting Copper Ores at the Hafod Works, by John Taylor, Esq. Treas. G.S.	The Author.
Feb. 10.	A Discovery of all Sorts of Mines and Minerals, by Mr. Gabriel Platte, 4to. London 1679.	W. C. Trevelyan, Esq., M.G.S.

1824.		BOOKS.	DONORS.
Mar.	2.	A Selection of the Geological Memoirs contained in the Annales des Mines, by H. T. De la Beche, Esq. F.G.S.	The Author.
April	1.	Sopra alcuni Pezzi di Granito e di Lave antiche trovati presso alla Cima dell' Etna. Osservazioni Fisiche del D. Carlo Gemmellaro di Catania.	The Author.
	8.	Observations sur les Fucoides, et sur quelques autres Plantes Marines Fossiles, par M. Adol. Brongniart.	The Author.
	18.	An Account of a Case of Recovery after the Shaft of a Chaise had been forced through the Thorax, by Will. Maiden, Esq., Mem. Roy. Coll. of Surgeons.	W. Clift, Esq. F.G.S.
		Selections from the Works of the Baron de Humboldt, relating to the Climate, Inhabitants, Productions, and Mines of Mexico; with Notes by John Taylor, Esq. Treas. G.S.	J. Taylor, Esq. Treas. G.S.
	26.	Philosophical Letters, between Mr. Ray and several of his Correspondents. London 1718.	W. C. Trevelyan, Esq. M.G.S.
		La Bibliothèque des Philosophes: par le Sieur Gauthier, 2 tomes, 8vo. Paris 1723.	.....
		Prospetto dei Minerali di Sicilia. Palermo 1808.	Sir H. Bunbury, Bt. M.G.S.
		Memoria dell' ultima Eruzione dell' Etna, accaduta il di' 27 di Marzo 1809: scritta da D.Benedetto Chiavetta.	.....
May	8.	Mémoire sur l'Application du Calcul aux Phénomènes Electro-dynamiques.	T. R. Underwood, Esq. M.G.S.
		Description des Coquilles Fossiles des Environs de Paris, par G. P. Deshayes, 1 Livraison. Paris 1824.	The Author.
	20.	Transactions of the Royal Society of Edinburgh, Vol.10, part 1.	The Royal Society of Edinburgh.
		Transactions of the Cambridge Philosophical Society, vol. 2, part 1.	Cambridge Phil. Soc.
		Monographie des Espèces Vivantes et Fossiles du Genre Mélanopside (Melanopsis), par M. D'Audebard de Ferussac, 4to. Paris 1823.	C. Lyell, Esq., Sec.G.S.
June	7.	A descriptive Catalogue of the Minerals in the Systematic Collection of the Museum of Trinity College, Dublin.	Dr. Stokes.
	29.	New Observations on the Natural History of this World of Matter, by Thos. Robinson. 1696.	Dr. Leach.
		Account of the Earthquake at Lima in 1746. London, 2nd edition, 1748.	W. C. Trevelyan, Esq. M.G.S.
		Printed Report on the Slate Quarries at Llanllechid, Carnarvon.	.....
Oct.	13.	Transactions of the Horticultural Society, vol. 5, part 4, with the Second Report of the Garden Committee.	Horticultural Society.
	22.	Memoria sobre la Leche del Arbol de la Vaca, por Mariano de Rivero y J. B. Boussingault.	The Authors.
Nov.	5.	Inquiries respecting the Geological Relations of the Beds between the Chalk and the Purbeck Limestone, in the S.E. Part of England, by W. H. Fitton, M.D., F.R.S.,&c.	The Author.
	19.	Transactions of the Linnean Society, vol. 14, part 2.	Linnean Society.

List of Donations.

1824.		BOOKS.	DONORS.
Dec.	1.	Annals of Philosophy, for the Year 1824.	The Editors.
	2.	American Journal of Science and Art, Nos. 1 and 2 of vol. 7., and Nos. 1 and 2 of vol. 8.	Dr. Silliman.
	7.	Transactions of the Royal Asiatic Society of Great Britain, vol. 1, part 1.	Royal Asiatic Society.
	18.	Memoirs of the Astronomical Society of London, vol. 1, part 2.	The Astronomical Society.
		Mémoires sur les Terrains Secondaires du Versant Nord des Alpes Allemands, par Ami Boué.	The Author.
	20.	Mémoires de la Société Linnéenne du Calvados, année 1824.	Linnean Society of Calvados.
	31.	Philosophical Magazine, for the Year 1824.	The Editors.
		Quarterly Journal of Science, Literature and the Arts, Nos. 33—36.	Royal Institution.
		A Natural Arrangement of British Plants, with an Introduction to Botany, by Sam. Fred. Gray, 2 vols. 1821.	J. E. Gray, Esq. M.G.S.
1825.			
Jan.	14.	Commentatio de Apenninorum Constitutione Geognostica: Io. Frid. Lud. Hausmanni. Gottingæ 1823.	The Author.
Feb.	1.	Catalogue of the Library of the American Philosophical Society at Philadelphia.	Phil. Soc. of Philadelphia.
		Chart of the State of Trade of Great Britain, by Cæsar Moreau, Esq.	The Author.
	7.	Tableau des Corps organisés Fossiles précédé de Remarques sur leur Pétrifaction, par M. Defrance.	The Author.
	8.	Travels in South America, during the years 1819—1821, by Alex. Caldcleugh, Esq.	The Author.
	20.	A Letter from L. W. Dillwyn, Esq., addressed to Sir Humphrey Davy, Bart. (2 copies.)	The Author.
	25.	Uebersicht der Jungeren Flötzgebilde im Fluszgebiete der Weser, von J. F. L. Hausman.	The Author.
Mar.	11.	Essai d'un Exposé Géognostico-botanique de la Flore du Monde primitif, par Gaspard, Comte de Sternberg, cahier 3.	The Author.
		Annales des Mines, tome 7, livraisons 2 & 3.	Conseil des Mines.
	19.	Mémoire Géologique sur les Terrains anciens et secondaires du Sud-ouest de l'Allemagne au Nord du Danube, par M. Ami Boué.	The Author.
April	9.	The Geology of Germany, by Charles Keferstein, 1st division of vol. 3.	The Author.
	22.	Histoire du Passage des Alpes par Annibal, par J. A. De Luc. Geneva 1818.	C. P. Meyer, Esq. M.G.S.
		Versuche uber die Wirkungen des Baryts &c., or Effects of Barytes, &c. on the Animal System, by C. G. Gmelin, M.D. of Tübingen in Suabia.	The Author.
May	1.	Prospectus of a School of Mines in Cornwall, by John Taylor, Esq.	J. Taylor, Esq. Treas. G.S.
		Description of the Process of Amalgamation, in a Letter from J. H. Vivian, Esq. to J. Taylor, Esq. Treas. G.S.	.....

1825.		BOOKS.	DONORS.
May	20.	On the Consolidation of the Strata of the Earth, by Sir James Hall, Bart.	The Author.
		Transactions of the Horticultural Society, vol. 5, part 5.	Horticultural Society.
		Description des Coquilles Fossiles des Environs de Paris, par G. P. Deshayes. Livraisons 2—9.	The Author.
		Transactions of the Linnean Society, vol. 14, part 3.	The Linnean Society.
June	3.	Observations sur les Végétaux Fossiles renfermés dans les Grès de Hoer en Scanie, par M. Ad. Brongniart.	The Author.
		An Attempt to establish the first Principles of Chemistry by Experiment, by T. Thompson, M.D.	The Author.
	22.	Mémoire Géologique sur l'Isle de Sardaigne, par M. le Chev. Albert de la Marmora.	M. L. Cordier, For.M.G.S.
		Another Copy.	M. Charles de Perron.
		Osservazioni sulle Rocce Pirigene della Valle di Fiemme, dei Signori Bertrand-Geslin, Trettenero, e Marischini.	Signor Marischini.
July	2.	Storia de' Fenomeni del Vesuvio, avvenuti nel Corso degli Anni 1821, 1822, e parte del 1823: di T. Monticelli e N. Covelli. 1823.	Lord Compton, F.G.S.
		Observations et Expériences faites au Vésuve pendant une partie des Années 1821 et 1822, par T. Monticelli et N. Covelli. 1822.	.....
		A Geological and Agricultural Survey of the District adjoining the Erie Canal, New York, taken under the Direction of the Hon. Stephen Van Rensselaer, part 1, 8vo. Albany 1824.	The Author.
		Tabellen über die Vergleichende Geognosie. Ein Versuch, von Christian Keferstein.	The Author.
		Teutschland Geognostisch-geologisch dargestellt und mit Charten und Durchschnitts, &c., von Christian Keferstein, 8vo. Weimar 1825.	The Author.
	22.	Observations sur quelques Systèmes de la Formation Oolitique du Nord-ouest de la France, par M. Desnoyers.	The Author.
		Notice sur le Fossile à Odeur de Truffes, par M. Jules Desnoyers.	The Author.
Aug.	29.	Mémoire Géologique sur les Environs de Bourdeaux, 1re partie, par M. De Basterot, F.G.S.	The Author.
Sept.	12.	Report of the Transactions of the Academy of Natural Sciences of Philadelphia for 1824.	The Academy of Sciences of Philadelphia.
		Annales des Mines, livraison 4 tome 7, tomes 8 & 9, et livraisons 1 & 2 tome 10.	Conseil des Mines.
		American Journal of Science and Art, vol. 9, no. 2.	Dr. Silliman.
		Observations on the Tin Trade of the Ancients in Cornwall, by Sir Christopher Hawkins, Bart.	M. Charles de Perron.
		Sulle Formazioni delle Rocce del Vicentino Saggio Geologico, di Pietro Maraschini.	The Author.
Oct.	3.	Transactions of the Royal Irish Academy, vol. 14.	R. I. Academy.
	21.	Considerations on Volcanos, the probable Causes of their Phenomena, &c., &c., by G. Poulett Scrope, Esq., Sec. G.S.	The Author.

1825.	BOOKS.	DONORS.
Nov. 3.	The Anti-Lancet, Nos. 1, 2, 3.	The Editor.
	Notice on the Iguanodon from the Sandstone of Tilgate Forest.	Gideon Mantell, Esq. F.G.S.
14.	An Essay on Egyptian Mummies, with Observations on the Art of Embalming among the ancient Egyptians, by A. B. Granville, M.D., F.G.S., &c.	The Author.
17.	Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce, vols. 1 to 42 inclusive.	Society of Arts.
Dec. 2.	Annals of Philosophy, for the Year 1825.	The Editors.
	Sketch of the Geology of Sicily, by C. Daubeny, M. D. F.G.S., Prof. Chem. Univ. Oxford.	The Author.
	Ueber den Ursprung der Vulkane in Italien, von Rudolph von Prystanowski.	Dr. Daubeny, F.G.S., &c.
21.	American Journal of Science and Art, vol. 10, no. 1.	Dr. Silliman.
28.	Remarks on the Cultivation of the Silk-worm, with additional Observations made in Italy in 1825, by John Murray, Esq. F.G.S.	The Author.
31.	Philosophical Magazine, for the Year 1825.	The Editors.
	Quarterly Journal of Science, Literature and the Arts, nos. 37—40.	Royal Institution.
1826.		
Jan. 7.	Transactions of the Horticultural Society, vol. 6, parts 1 and 2; with the Report of the Committee for 1825.	Horticultural Society.
Feb. 3.	Mémoire sur l'Accroissement des Polypes Lithophytes considéré géologiquement, par MM. Quoy et Gaimard.	The Authors.
17.	Catalogue of the Shells in the Collection of the late Earl of Tankerville.	Charles Stokes, Esq. F.G.S.
	Transactions of the Society of Arts. vols. 43 & 44.	Society of Arts.
Mar. 24.	Religiosa Philosophia; or a new Theory of the Earth, by W. Welch, of Stonehouse, Devon.	W. C. Trevelyan, Esq., F.G.S.
	Thomæ Guidotti Anglo-Britanni de Thermis Britannicis Tractatus: accesserunt Observationes Hydrostaticæ, Chromaticæ, et miscellaneæ: uniuscujusque Balnei apud Bathoniam, Naturam, Proprietatem, et Distinctionem curatius exhibentes.	.....
	Transactions of the American Philosophical Society, vol. 2, N. S.	American Phil. Society.
	Memoirs of the Astronomical Society of London, vol. 2, parts 1 and 2.	Astronomical Society.
	Transactions of the Royal Asiatic Society, vol. 2, part 1.	Royal Asiatic Society.
May 4.	100 Copies of printed Instructions for collecting Geological Specimens. (To be given to Members.)	Dr. Fitton, V.P.G.S.
	An Account of some Geological Specimens from the Coasts of Australia, by W. H. Fitton, M.D. V.P.G.S.	.....
	Antediluvian Phytology, illustrated by a Collection of the Fossil Remains of Plants peculiar to the Coal Formations of Great Britain, by E. Tyrrel Artis, Esq. F.G.S.	The Author.

1826.	BOOKS.	DONORS.
May 5.	Physicalische Beschreibung der Canarischen Inseln, von Leopold von Buch, (with an Atlas.)	The Author.
	Mémoire sur la Craie et sur les Terrains Tertiaires du Cotentin, par M. J. Desnoyers.	The Author.
June 2.	Mineralogische Beschreibung des Hochstifts Fuld und einiger merkwürdigen Gegenden am Rhein und Mayn, von Joh. Carl. Wilh. Voight.	Dr. Daubeny, F.G.S.
	Beyträge zur nähern Kenntnisz des Flöz-Sandsteins und einigen Geologischen Gedakeen, von Georg. Christian Sartorius. 1809.	.....
	Theorie der Verschiebungen älterer gänge mit Andwendung auf den Bergbau. Ein Beitrag zur allgemeinen Gangtheorie, von Johann. Christian Lebrecht Schmidt.	.....
	Geognostische Beobachtungen und Erfahrungen vorzüglich in Hinsicht des Basaltes, von Georg. Christian Sartorius.	.....
	Nachtrag zu den Geognostischen Beobachtungen und Erfahrungen, von G. Chr. Sartorius.	.....
8.	American Journal of Science and Arts, vol. 10, No. 2.	Dr. Silliman.
12.	Mineralogische Reise nach den Braunkohlenwerken und Basalten in Hessen, wie auch nach den Schieferkohlenwerken des Unterharzes, von Joh. Carl. Wilh. Voight.	Dr. Daubeny, F.G.S.
	Taschenbuch fur Reisende in den Hartz, von Friedrick Gottschalck.	.....
	Transactions of the Horticultural Society of London, vol. 6, part 3, with the Report of the Committee.	Horticultural Society.
	A Description of active and extinct Volcanoes, by Chas. Daubeny, M.D. F.G.S. R.S., &c.	The Author.
July 7.	Transactions of the Berlin Academy for 1820-21 and 1821-22.	Royal Academy of Berlin.
Aug. 1.	Discours sur les Revolutions de la Surface du Globe, et sur les Changemens qu'elles ont produits dans le Règne Animal, par M. le Baron G. Cuvier, For. M.G.S. &c. &c.	The Author.
	Transactions of the American Philosophical Society, vol. 3, no. 1, N. S.	American Phil. Soc.
Sept. 6.	Asiatic Researches, or Transactions of the Asiatic Society. vol. 15. Bengal.	The Asiatic Society.
10.	Transactions of the Royal Society of Edinburgh, vol. 10, part 2.	Royal Society of Edinburgh.
	Sixth Report of the Council of the Leeds Philosophical and Literary Society.	Leeds Phil. and Lit. Society.
Oct. 8.	Annales des Mines, livraisons 3—6. 1825.	Conseil des Mines.
	Reliquiæ Conservatæ, from the primitive Materials of our present Globe, with popular Descriptions of the prominent Characters of some remarkable Fossil Encrinites, by George Cumberland, Esq.	The Author.
	Geological and Historical Observations on the Eastern Valleys of Norfolk, by J. W. Robberds, jun.	The Author.

1826.		BOOKS.	DONORS.
Oct.	8.	De l'Arkose, Caractères Minéralogiques et Histoire Géognostique de cette Roche, par Alex. Brongniart, For. M.G.S.	The Author.
	12.	American Journal of Science and Arts, vol. 11, no. 1.	Dr. Silliman.
		Catalogue of Rocks and Fossils collected in the Neighbourhood of Midhurst, Sussex, by the Rev. C. P. N. Wilton, M.A.	The Author.
		Noticia sobre el Rio llamado Vinagre, por Don Mariano Rivero, Director-jeneral de minas del Perú.	The Author.
		Transactions of a Society for the Natural Sciences at Wirtemberg in Suabia.	Dr. C. G. Gmelin, For. M.G.S.
		Résumé Géologique sur les Ossemens Fossiles, par M. J. J. N. Huot, Mem. Soc. d'Hist. Nat. Paris.	The Author.
		Elementary Treatise on Mineralogy and Geology, by Parker Cleaveland.	Dr. Hossack.
Dec.	1.	Catalogue systematique des Livres de la Bibliothèque de Paul de Demidoff, Mem. de la Société Imper. de St. Petersbourg, &c.	Sir Alex. Crichton, V.P.G.S.
		Museum Leskeanum, 3 vols.	.....
		Catalogue Raisonné d'une Collection choisie de Mineraux, Cristallizations, Madrépores, Coquilles, et autres Curiosités de la Nature et de l'Art, 1769.	.....
		Introduction à l'Etude des Corps naturelles, tirés du Règne Mineral, par M. Bucquet, M.D. 1671.	.....
		Versuche über die Chemische Zerlegung des Luftkreises und über einige andere Gegenstände der Naturlehre, von Alexander von Humboldt.	.....
		Aphorismen aus der Chemischen Physiologie der Pflanzen, von Alexander von Humboldt, 1794.	.....
	15.	Description Methodique d'une Collection de Mineraux du Cabinet de M.D.R.D.L., par M. de Romé Delisle, 1773.	.....
		Memoirs of the Astronomical Society of London, vol. 2, part 2.	Astronomical Society.
		Illustrations of the Geology of Sussex, by Gideon Mantell, Esq. F.G.S.	The Author.
		Philosophical Magazine for the Year 1826.	The Editors.
		Annals of Philosophy, ditto.	The Editors.
1827.			
Jan.	1.	Memoria sopra i Tremuoti della Sicilia in Marzo 1823, del Signor Abate Francesco Ferrara.	The Author.
	9.	Introduction to the Study of Mineralogy, by Joseph Backwell, Esq.	The Author.
	10.	Transactions of the Horticultural Society, vol. 6, part 4.	Horticultural Society.
		An Historical Account of Earthquakes, by the Rev. T. Hunter.	W. C. Trevelyan, Esq. F.G.S.
		Geographical Description of the State of Louisiana, by William Darby.	.....

1827.		BOOKS.	DONORS.
Feb.	2.	Geognostische Umrisse der Rheinländer zwischen Basel und Mainz, durch C. v. Oeynhausen, H. v. Dechen, H. v. la Roche. Essen, (2 vols. with maps.)	The Authors.
		Versuch einer Geognostischen Beschreibung von Oberschlesien und den nächst angrenzenden Gegenden von Polen, Galizien und östreichisch-Schlesien, von Carl von Oeynhausen.	The Author.
Mar.	2.	Mémoire sur les Dépressions de la Surface du Globe dans le Sens longitudinal des Chaines de Montagnes et entre deux Reliefs Maritimes adjacens, par M. le Lieutenant-général d'Artillerie Comte Andréossy.	The Author.
		Transactions of the Linnean Society, vol. 15, part 1.	Linnean Society.
April	6.	Report of the Yorkshire Philosophical Society for 1826.	Yorkshire Phil. Soc.
		Transactions of the Horticultural Society, vol. 6, part 5.	Horticultural Society.
		Mémoires de l'Académie Royale des Sciences de l'Institut de France, années 1821 et 1822, tom. 5.	Royal Academy of Sciences of France.
		Mémoires presentées par divers Savans à l'Académie Royale des Sciences de l'Institut de France, tom. 1.	.....
	20.	Examen Analytique de la Conférence de Mgr. l'Evêque d'Hermopolis, dans laquelle Moïse est considéré comme Historien des Temps primitifs, par le Baron de Férussac.	The Author.
May	4.	Classification et Caractères Minéralogiques des Roches homogènes et hétérogènes, par Alex. Brongniart, For. M.G.S.	The Author.
		Essai Géologique sur la Montagne de Bontade près Issoire, Département du Puy-de-Dôme, par MM. Dévèze de Chabriol et J. B. Bouillet.	M. J. B. Bouillet.
	18.	Memoirs of the Board of Agriculture of the State of New York, vols. 2 & 3.	G. W. Featherstonhaugh, Esq.
		Edicts, Ordonnances, Arrests, et Réglemens sur le Faict, Ordre, et Police des Mines, &c. de France, depuis le Roy Charles VI. jusques à Louis XIII. à présent régnant.	W.C.Trevelyan, Esq. F.G.S.
		Fabii Columnæ Opusculum de Purpura, nunc iterùm luci datum, Operâ ac Studio Johan. Danielis Majoris, Med. D.	.....
		Memoria sobre a nova Mina de Ouro da outra Banda do Tejo. Lida em 10 de Maio de 1815, por José Bonifacio de Andrada e Silva.	.....
		Memoria sobre as Pesquizas e Lavra dos Veios de Chumb de Chacim, Souto, Ventozello, e Villar de Rey na Provincia de Tras os Montes, por José Bonifacio de Andrada e Silva.	.....
		De Corporibus Marinis Lapidescentibus quæ de Fossa reperiuntur, auctore Augustino Scilla.	.....
		Fossilia Hantoniensa, by Gustavus Brander.	Miss Benett.
		Proceedings of the Astronomical Society, Nos. 1, 2, 3.	Astronomical Society.

1827.	BOOKS.	DONORS.
May 18.	Bemerkungen über den Steinkohlenbergbau in den Niederlanden und in dem angränzenden Theil des Nördlichen Frankreichs, von den Herren von Oeynhausen und von Dechen.	The Authors.
	Jahrgang 1825, Erst stuck, von Professor Weiss.	The Author.
June 1.	Chemical Manipulation; being Instructions to Students in Chemistry, by Michael Faraday, Esq. F.R.S. &c.	The Author.
	Essai d'une Exposé Géognostico-botanique de la Flore du Monde primitif, par Gaspard Comte de Sternberg, traduit par Comte de Bray.	Comte de Sternberg.
	On the Geology of East Norfolk; with Remarks upon the Hypothesis of Mr. J. W. Robberds respecting the former level of the German Ocean, by R. C. Taylor, Esq. F.G.S.	The Author.
	Coup-d'Oeil Minéralogique et Géologique sur la Province du Hainaut, Royaume des Pays-Bas, par M. Drapiez.	The Author.
22.	Some Account of the Science of Botany, being the Substance of an Introductory Lecture to a Course on Botany, delivered in the Theatre of the Royal Institution of Great Britain, by John Frost, F.A.S. &c.	The Author.
	Quarterly Journal of Science, Literature and the Arts, Nos. 41, 42, 43, 44.	The Royal Institution.
July 2.	Transactions of the Horticultural Society, vol. 7, part 1, and Report of the Garden Committee.	Horticultural Society.
	Proceedings of the Astronomical Society, Nos. 4 and 5.	Astronomical Society.
9.	Mémoires de l'Académie Royale des Sciences de l'Institut de France, tom. 6.	Royal Academy of Sciences, France.
	American Journal of Science and Arts, vol. 11 part 2, and vol. 12 part 1.	Dr. Silliman.
	Eulogium on Thos. Jefferson, delivered before the American Philosophical Society, by Nicholas Biddle.	The Author.
	Theorie der Verschiebungen älterer Gänge mit Anwendung auf den Bergbau, Joh. Chr. Lebrecht Schmidt.	The Author.
	Memoirs of the Wernerian Society, vol. 5, part 2.	The Wernerian Society.
18.	Die Phonolith-Berge der Rhön, von K. C. Leonhard.	The Author.
Aug. 9.	Transactions of the Cambridge Philosophical Society, vol. 2, part 2.	Cambridge Phil. Society.
	Quadro delle Formazioni, che serve d'Indice, all' Essai Géognostique sur le Gisement des Roches dans les deux Hémisphères del Sig. Barone di Humboldt. Publicato da Guiseppe Marzari Pencati.	The Author.
31.	Outlines of a System of Surveying, by Major T. L. Mitchell, F.G.S.	The Author.
Oct. 16.	American Journal of Science and Arts, vol. 12 No. 2, and vol. 13 No. 1.	Dr. Silliman.
27.	Transactions of the Royal Asiatic Society of Great Britain, vol. 1.	Royal Asiatic Society.
Nov. 1.	Biography of Werner, by Dr. S. G. Frisch.	The Author.

1827.		BOOKS.	DONORS.
Nov.	12.	First and Second Annual Reports of the Literary and Philosophical Society, Kingston-upon-Hull, with the Laws.	J. Crosse, Esq. F.G.S.
	13.	On Systems and Methods in Natural History, by J. E. Bicheno, Esq. F.R.S. Sec. L.S. F.G.S. &c.	The Author.
	16.	On the Natural Embankments formed against the German Ocean, on the Norfolk and Suffolk Coasts, by R. C. Taylor, Esq. F.G.S.	The Author.
	22.	Essai sur la Température de l'Intérieure de la Terre, par M. L. Cordier, For. M.G.S.	The Author.
	27.	Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin.	Royal Academy of Science, Berlin.
		Preisschrift über genaue Messung der Winkel an Krystallen, von Dr. A. T. Kupffer.	.....
		Bericht über die Naturhistorischen Reisen der Herren Ehrenberg und Hemprich.	.....
Dec.	1.	Philosophical Magazine and Annals of Philosophy, 1827.	R. Taylor, Esq.
		Transactions of the American Philosophical Society, vol. 3, part 1, New Series.	American Phil. Soc.
	4.	Sketch of a Journey through the Western States of North America, by Wm. Bullock, Esq. F.G.S. F.L.S. &c.	The Author.
	8.	Catalogue of Foreign Books, 1828, Dulau and Co.	Dulau and Co.
	14.	Transactions of the Linnean Society, vol. 15, part 2.	Linnean Society.
		Reports (1st, 2nd, and 3rd,) of the Directors, addressed to the Shareholders, of the Imperial Brazilian Mining Association.	J. L. Goldsmid, Esq. F.G.S.
	27.	Memoirs of the Astronomical Society, vol. 3, part 1.	Astronomical Society.
1828.			
Jan.	14.	Transactions of the Society of Arts, vols. 44 and 45.	The Society of Arts.
		Quarterly Journal of Science, Literature and Art, New Series, No. 4.	The Royal Institution.
		Packe's Chorographical Chart of East Kent, in 4 sheets, with ΑΝΚΟΓΡΑΦΙΑ, in 4to.	W. O. Hammond, Esq. of Alban's Court, Wingham.
	31.	Philosophical Magazine and Annals, New Series, No. 14.	R. Taylor, Esq.
Feb.	29.	Philosophical Magazine and Annals, New Series, No. 15.	.....
Mar.	14.	Bye-laws of the Medico-Botanical Society of London.	The Council of the Medico-Botanical Society.
April	2.	Quarterly Journal of Science, Literature and Art, New Series, No. 5.	The Royal Institution.
		Geognostic Memoir of the Island of St. Michael, by Senhor Mousinho D'Albuquerque, Royal Mint, Lisbon.	The Author, through Lord Heytesbury.
	7.	Proceedings of the Astronomical Society, Nos. 8 and 9.	The Astronomical Society.
		Observations on the Jaw of a Fossil Mammiferous Animal, found in the Stonesfield Slate, by W. J. Broderip, Esq. Sec. G.S. F.R.S. &c.; with Remarks on the Strata whence the Fossil was obtained, by W. H. Fitton, M.D. Pres. G.S. F.R.S. &c.	W. J. Broderip, Esq. Sec. G.S. F.R.S. &c.
		Notice on a Dike of Serpentine in the County of Forfar, by C. Lyell, Esq. V.P.G.S. &c.	The Author.

1828.	BOOKS.	DONORS.
April. 15.	Mémoire sur les Bélemnites considerées zoologiquement et géologiquement, par M. H. Ducrotay de Blainville.	The Author.
18.	Prodromus of a Synopsis Animalium contained in the Museum of Joshua Brookes, Esq.	The Author.
	A Geological Memoir on a Part of Western Sussex; with some Observations upon Chalk Basins, the Weald Denudation, and Outliers by Protrusion, by P. J. Martin, Esq.	The Author.
25.	Lithographic Print of Producti.	M. F. G. Höninghaus.
	Annual Report of the Yorkshire Phil. Soc., 1827.	The Yorkshire Phil. Soc.
26.	Contributions of the Maclurian Lyceum to the Arts and Sciences, Nos. 1 and 2, vol. 1.	The Philadelphia Maclurian Lyceum.
May 1.	Mémoires de l'Académie Royale des Sciences de l'Institut de France, vol. 7.	The Royal Institute of France.
	The Osteology of the Chlamyphorus truncatus of Dr. Harlan, by Wm. Yarrell, Esq. F.L.S. &c.	The Author.
13.	Observations Géologiques sur les différentes Formations qui, dans le Système des Vosges, séparent la Formation Houillère de celle du Lias, par M. L. Elie de Beaumont, Ingénieur des Mines.	The Author.
	Mémoire sur l'Existence du Gypse et de divers Minérais métalifères dans la Partie Supérieure du Lias du Sud-ouest de la France, par M. Dufrénoy, Ingénieur des Mines.	The Author.
	Voyage Métallurgique en Angleterre, ou Recueil de Mémoires sur le Gisement, l'Exploitation et le Traitement des Minérais, d'Etain, de Cuivre, de Plomb, de Zinc, et de Fer, dans la Grande Brétagne, par MM. Dufrénoy et Elie de Beaumont.	The Authors.
16.	Auffindung und Ausgrabung einer 8 Leipz. Ellen $5\frac{3}{4}$ Zoll langen Blitzröhre bei Dresden, von Karl Gustav. Friedler, Dr. Ph. des prakt. Berg-u. Hüttenwes, willen zu Frieberg im Erzgebirge.	The Author.
19.	Proceedings of the Astronomical Society of London, No. 10.	The Astronomical Society.
21.	Transactions of the Horticultural Society of London, vol. 7, part 2.	The Horticultural Society.
29.	Essai Géologique et Minéralogique sur les Environs d'Issoire, Département du Puy-de-Dôme, et principalement sur la Montagne de Boulade, 5e et dernière livraison, par J. S. Devèze de Chabriol, ancien Elève de l'Ecole Polytéchnique, Membre Corréspondant de la Société Royale et Centrale d'Agriculture de Paris, &c., et J. B. Bouillet, Membre de la Société d'Encouragement pour l'Industrie Nationale, et de la Société Académique des Sciences, Belles-Lettres et Arts de Clermont-Ferrand.	M. Bouillet, jun.
June 3.	Report of the Proceedings of the First General Meeting of the Subscribers to the Oriental Translation Fund.	Royal Asiatic Society.

1828.	BOOKS.	DONORS.
June	6. An Essay on Mineralogical Classification and Nomenclature; with Tables of the Orders and Species of Minerals, by W. Whewell, M.A. F.R.S. F.G.S. Fellow of Trinity College, and Professor of Mineralogy in the University of Cambridge.	The Author.
	11. Mémoire Géologique sur les Terrains du Bas-Boulonnais, et particulièrement sur les Calcaires compactes ou grenus qu'il renferme, par F. Garnier, Ingénieur au Corps Royal des Mines.	The Author.
	14. Philosophical Transactions of the Royal Society of London, 1828, part 1.	Royal Society.
	American Journal of Science and Arts, vol. 14, No. 1, April, 1828.	Dr. Silliman.
	24. Proceedings of the Astronomical Society of London, No. 12.	The Astronomical Society of London.
July	1. Memoria sobre las Aguas Minerales de Yura, y otros Puntos cercanos a Arequipa, por Mariano Eduardo de Rivero, Director jeneral de Mineria, e Inspector Jeneral de Instruccion Publica del Peru, &c. &c. Lima 1827.	The Author.
	Memoria sobre el Guano de Pajaros, y su uso en el Peru, por Mariano Eduardo de Rivero, Director Jeneral de Mineria, &c. Lima 1827.	The Author.
	Memorial de Ciencias Naturales y de Industria Nacional y Extranjera, reductato por M. De Rivero y N. De Pierola.	The Authors.
	14. Narrative of a Second Expedition to the Shores of the Polar Sea in the Years 1825, 1826, and 1827, by John Franklin, Esq., Captain R.N. F.R.S. &c., and Commander of the Expedition; including an Account of the Progress of a Detachment to the Eastward, by John Richardson, M.D. F.R.S. L.S. &c., Surgeon and Naturalist to the Expedition.	The Authors.
	Report of the Commissioners appointed by His Majesty to inquire into the State of the Supply of Water in the Metropolis, dated April 21st, 1828.	Dr. Roget.
	Six Maps in illustration of Captain Franklin's Second Expedition to the Polar Sea.	J. Murray, jun., Esq.
	30. Spicilegia Zoologica: or Original Figures and short systematic Descriptions of new and unfigured Animals, by John Edward Gray, Esq., F.G.S. M.R.S.L. Honorary Member of the Philosophical Society of Colchester, Corresponding Member of the Maclurian Lyceum.	The Author.
Aug.	14. Proceedings of the Fifth Annual Meeting of the Bristol Institution.	The Bristol Institution.
Sept.	3. Mémoire sur divers Débris de Mastodontes á dents etroites, ou Mastodontes de Simorre, &c., par M. Marcel de Serres, Membre Corréspondant de la Société Linnéenne à Montpellier.	The Author.

1828.	BOOKS.	DONORS.
Oct. 1.	Catalogue méthodique et raisonné de la Collection des Fossiles de Mademoiselle Eléonore de Raab, par M. de Born, 2 vols.	C. Stokes, Esq.
	Voyage Minéralogique fait en Hongrie et en Transylvanie, par M. de Born.	G. B. Greenough, Esq.
14.	Eighth Report of the Council of the Leeds Philosophical and Literary Society, 1827—8.	The Leeds Philosophical and Literary Society.
	The American Journal of Science and Arts, vol. 14, No. 2, July 1828.	Dr. Silliman.
	Programme d'un Concours pour le Percement de Puits forés suivant la Méthode Artésienne, à l'Effet d'obtenir des Eaux jaillissantes applicables aux Besoins de l'Agriculture, &c., par M. le Viscomte Héricart de Thury, Conseiller d'Etat, Membre de l'Académie des Sciences, &c. 2 Copies.	The Author.
27.	Proceedings of the Astronomical Society of London, No. 13.	The Astronomical Society.
Nov. 14.	Harding and Lepard's Catalogue, part 1.	Messrs. Harding & Lepard.
15.	Transactions of the American Philosophical Society, vol. 3, part 2, New Series.	American Philosophical Society.
17.	Notice sur les Brèches osseuses et les Minérais de Fer pisiforme de même position géognostique, par M. Alexandre Brongniart, de l'Académie Royale des Sciences, Professeur de Minéralogie, &c.	The Author.
21.	Försör till Framställning af Kemiska Mineral-Systemet, af Nils Nordenskiöld.	The Author.
Dec. 5.	Récherches sur les Ossemens Fossiles du Département du Puy-de-Dôme, par l'Abbé Croizet et Iobert ainé.	The Authors.
13.	Description Géognostique du Bassin du Bas-Boulonnais, par M. Rozet, Officier au Corps Royal des Ingénieurs Géographes, Membre de la Société d'Histoire Naturelle, Correspondant des Sociétés Linnéenne de Normandie et d'Agriculture de Boulogne-sur-Mer.	The Author.
	Note sur la Présence de la Webstérite dans l'argile plastique d'Auteuil près Paris, par M. Alexandre Brongniart, de l'Académie Royale des Sciences, Professeur de Minéralogie au Jardin du Roi.	The Author.
	Notice sur des Blocs de Roches des Terrains de Transport en Suède, par M. Alexandre Brongniart, de l'Académie Royale des Sciences, &c.	The Author.
18.	Description of a New Species of Cypræa, by W. J. Broderip, Esq., Sec. G.S. F.R.S. F L S., &c.	The Author.
	Observations on the Animals hitherto found in the Shells of the Genus Argonauta; by W. J. Broderip, Esq., Sec. G S. F.R.S. F.L.S., &c.	The Author.
	On the Habits and Structure of Paguri and other Crustacea, by W. J. Broderip, Esq., Sec. G.S. F.R.S. F.L.S., &c.	The Author.

1828.	BOOKS.	DONORS.
Dec. 18.	Description of a New Land Shell from South America, by W. J. Broderip, Esq., Sec. G.S. F.R.S. F.L.S., &c.	The Author.
19.	Notices sur les Cavernes à Ossemens Fossiles des Carrières du Calcaire Grossier, situées aux Environs de Lunel-Vieil, Département de l'Hérault, par M. Marcel de Serres.	The Author.
30.	The First and Thirty-third Books of Pliny's Natural History: a Specimen of a proposed Translation of the whole Work, with Notes, &c., by John Bostock, M.D. F.R.S. F.L.S. F.G.S. & F.H.S. M.R.I.A. Member of the Medico-Chirurgical, of the Astronomical, and of the Zoological Societies, &c., 1828.	The Author.
	Memoir on the Geology of Central France, including the Volcanic Formations of Auvergne, the Velay, and the Vivarais, 1 vol. 4to, with an Atlas of Maps and Plates, by G. Poulett Scrope, Esq., F.R.S. F.G.S., &c.	The Author.
1829.		
Jan. 1.	Philosophical Magazine, No. 13 to 24, New Series.	R. Taylor, Esq., F.G.S.
	Quarterly Journal of Science, Literature and Art, Nos. 6, 7, and 8, New Series.	Royal Institution.
	Magazine of Natural History, Nos. 1, 2, 3, 4, and 5.	J. C. Loudon, Esq., F.G.S. Conductor.
	Journal de Physique for Jan., Feb., Mar., April, May, and June, 1823.	R. Ferguson, Esq. F.G.S.
2.	The American Journal of Science and Arts, vol. 15, No. 1, Oct., 1828, conducted by B. Silliman, M.D. LL.D., &c.	The Conductor.
10.	An Address delivered at the Anniversary Meeting of the Zoological Club of the Linnean Society, held at the Society's House, in Soho Square, Nov. 29, 1828, by Joshua Brookes, Esq., F.R.S. F.L.S., &c.	The Author.
	Second Part of Harding and Lepard's Catalogue of Books, 1829.	Messrs. Harding & Lepard.
	Mémoire sur un Silicate d'Alumine considéré sous les Rapports Chimique, Minéralogique, et Géognostique, par M. A. Engelspach-Larivière, Membre de la Commission de Statistique du Brabant Méridional, et de plusieurs Sociétés Savantes.	The Author.
	Essai Géognostique sur les Environs de Saint-Pétersbourg, par A. Engelspach-Larivière, Membre de plusieurs Sociétés Savantes.	The Author.
	Description Géognostique du Grand Duché de Luxembourg, suivie de Considérations Economiques sur les Richesses Minerales, par A. Engelspach-Larivière, Ingénieur des Mines, Membre de plusieurs Sociétés Savantes. Bruxelles 1828.	The Author.
28.	Transactions of the Royal Society of Edinburgh, vol. 11, part 1.	The Royal Society of Edinburgh.
29.	Description de trois Gènres nouveaux de Coquilles Fos-	

1829.	BOOKS.	DONORS.
	siles du Terrain Tertiaire de Bourdeaux, savoir: SPIRICELLA, par M. Rang, Lieut. de Vaisseau, &c., et GRATELUPIA et JOUANNETIA, par M. Charles des Moulins, Président de la Société Linnéenne de Bourdeaux.	The Authors.
Feb.	3. Prodrome d'une Histoire des Végétaux Fossiles, par M. Adolphe Brongniart, Docteur en Médecine, &c.	The Author.
	Notice sur un Gisement de Végétaux Fossiles et de Bélemnites, situé à Petit-Cœur près Moutiers en Tarentaise, par M. L. Elie de Beaumont.	The Author.
	6. Records of Mining, edited by John Taylor, Esq. F.R.S. Treasurer to the Geological Society, &c.	The Editor.
	Address of Earl Stanhope, President of the Medico-Botanical Society, at the Anniversary Meeting, Jan. 16, 1829.	Earl Stanhope.
	12. Transactions of the Royal Asiatic Society, part 1, vol. 2.	The Royal Asiatic Society.
	Transactions of the Linnean Society of London, vol. 16, part 1.	The Linnean Society.
	List of the Zoological Society, 1829.	The Zoological Society.
	20. Additional Observations on the Anticlinal Line of the London and Hampshire Basins, &c., by P. J. Martin, Esq.	The Author.
	21. The American Journal of Science and Arts, vol. 15, No. 2.	Dr. Silliman.
	23. Reply to a Letter in the Morning Chronicle relative to the Interest which the British Government evinces in the Promotion of Astronomical Science, by James South, Esq. Vice President of the Astronomical Society of London, F.R.S. L. and E. &c.	The Author.
	An Attempt to form a Table of the Geological Arrangement of British Fossil Shells, by R. C. Taylor, Esq. F.G.S.	The Author.
Mar.	3. Transactions of the Royal Irish Academy, vol. 15.	Royal Irish Academy.
	4. Narrative of an Ascent to the Summit of Mont Blanc on the 8th and 9th Aug. 1827, by John Auldjo, Esq. of Trin. Coll. Cambridge, F.G.S.	The Author.
	9. Delle Pietre Antiche, Libri quattro di Faustino Corsi Romano. Roma 1828.	The Marquis of Northampton, F.G.S.
	19. Les Continens Actuels ont ils été, à plusieurs réprises, submergés par la Mer? Dissertation Géologique, par M. Constant Prevost, For. M.G.S.	The Author.
	Mémoire sur le Mont Somma, par M. L. A. Necker, For. M.G.S.	The Author.
	A Geological Survey of the Yorkshire Coast, describing the Strata and Fossils occurring between the Humber and the Tees, from the German Ocean to the Plain of York, by the Rev. George Young, A.M. &c.	The Author.
	31. Quarterly Journal of Science, Literature, and Art, N. S. No. 9.	The Royal Institution.
April	8. Essai d'une Flore du Grès Bigarré, par M. Adolphe Brongniart.	The Author.

List of Donations.

1829.	BOOKS.	DONORS.
April 15.	Proceedings of the Astronomical Society of London, Nos. 16 and 17.	The Astronomical Society of London.
24.	Aperçu des Minéraux des deux Départements du Rhin, par M. Voltz, Ingénieur des Mines.	The Author.
28.	The Travels of Ibn Batūta, translated from the abridged Arabic Manuscript Copies preserved in the public Library of Cambridge; with Notes illustrative of the History, Geography, Botany, Antiquities, &c., occurring throughout the work, by the Rev. Samuel Lee, B.D. &c.	The Royal Asiatic Society.
30.	On some further Improvements in Lithographic Printing.	Mr. Hullmandel.
	Philosophical Magazine and Annals, No. 29, May.	R. Taylor, Esq. F.G.S.
May 1.	Magazine of Natural History, No. 7.	J.C.Loudon, Esq.F.G.S.
4.	Refutation of the numerous Misstatements and Fallacies contained in a Paper presented to the Admiralty by Dr. Thomas Young, by James South, Esq. F.R.S.	The Author.

II. *Donations to the Collections of Maps, Sections, &c.*

1823.	MAPS, &c.	DONORS.
Aug. 19.	Chart of the Ferroe Islands.	W.C.Trevelyan, Esq. F.G.S.
1824.		
Jan. 2.	MS. map of New Holland and New South Wales.	Capt. King, R.N.
May 8.	Print of the Megatherium, found near Buenos Ayres.	James Hall, Esq.
20.	Drawing of a submarine forest on the Severn near Bridgwater.	H. T. De la Beche, Esq. F.G.S.
	Drawing of Cape Pillar, Van Dieman's Land.	P. B. Webb, Esq. F.G.S.
Nov. 5.	Sections of part of the coasts of the Isle of Wight and the Isle of Purbeck.	Dr. Fitton, Sec.G.S.
19.	An engraving of fossil plants.	Gideon Mantell, Esq. F.G.S.
1825.		
April 9.	Ordnance map of Lincolnshire and Rutlandshire.	Major Colby, F.G.S.
22.	Carte physique et mineralogique du Mont Blanc, par M. I. B. Raymond.	C. P. Meyer, Esq. F.G.S.
Aug. 29.	Carte physique de l'Ile de Palma, par M. Leopold de Buch, F.R.S. For. M.G.S.	M. Leopold de Buch, For. M.G.S.
Sept. 1.	Profils de la Peninsule Espagnole, par M. Alexandre de Humboldt, F.R.S. For. M.G.S.	M. Alex. de Humboldt, For. M.G.S.
Oct. 1.	Lithographic print of Ovula tuberculosa.	M. Duclos.
1826.		
Jan. 7.	Five drawings of a fossil fish, found in the Yorkshire Coalfield.	John Atkinson, Esq. and Edw. Sanderson George, Esq.
May 5.	Lithographic print of a Mammoth's tooth, found near Crefeld.	M. Fred. G. Hoeninghaus.
	Map of the Hartz, by Frederick Julius.	Dr. Leschen of Göttingen.
	Engraved portrait of Baron von Humboldt.	.....

1826.		MAPS, &c.	DONORS.
Aug.	1.	Geological map of Sicily.	Dr. Daubeny, F.G.S.
Nov.	17.	Engraving of a new Encrinite.	G. Cumberland, Esq. Hon. M.G.S.
Dec.	1.	Carte specielle et petrographique du Mont St. Gothard et de ses environs, par le Père Placidus.	— Brockenden, Esq.
1827.			
April	20.	Six sheets of the New Atlas of India in preparation under the orders of the Court of Directors of the Hon. the East India Company.	Court of Directors of the Hon. the East India Company.
May	18.	Print of the mountain Rossberg in Switzerland.	W. C. Trevelyan, Esq. F.G.S.
July	2.	Design for the Garden in the Regent's Park, belonging to the Zoological Society.	The Council of the Zoological Society.
	18.	Print of Aspergillum leognanum.	M. Fred. G. Hoeninghaus.
Nov.	2.	Map of Sweden, Norway, and Lapland.	Capt. De Capell Brooke.
	30.	Lithographic prints of Dapedium politum and Ichthyosaurus intermedius.	Viscount Cole, F.G.S.
Dec.	21.	Tabular view of volcanic phænomena, comprising a list of the burning mountains which have been noticed at any time since the commencement of historical records, &c. By Charles Daubeny, M.D. F.G.S. F.R.S. &c.	The Author.
1828.			
May	1.	Carta geognostica de los principales Distritos Minerales del Estado de Mexico, &c. Hechas por Frederico de Gerolt y Carlos de Berghes. Düsseldorf.	The Author, through J. Taylor, Esq. Treas. G.S.
1829.			
Jan.	3.	Ten sheets of a map of India, with a plan of the trigonometrical operations, carried on in the Peninsula of India, from the year 1812 to 1814 inclusive, under the superintendence of Lieut. Col. W. Lambton.	The Directors of the Hon. the East India Company.
June	3.	A geological map and three sections of a part of Western Sussex.	G. P. Martin, Esq.
		Lithographic print of a plant, found in the colliery of Moses Moses, Esq. at Abercarn, Monmouthshire.	M. Moses, Esq.
July	14.	Six maps in illustration of Capt. Franklin's second expedition to the Polar Regions.	J. Murray, jun., Esq. F.G.S.
Dec.	1.	Lithographic print of a block of granite, which lay near Fürstenwald in the Dutchy of Brandenburg.	Rev. J. Yates, F.G.S.

III. *Donations to the Cabinet of Minerals.*

1823.	SPECIMENS.	DONORS.
Nov. 6.	Cast of the jaw of a Mastodon, found in Austria.	Count Breunner, For. M.G.S.
1824.		
Jan. 10.	Specimens from different parts of the Rajemahal Hills, along the course of the Ganges, between Soorujgurah on the West, and Rajmahal on the East. Collected by Capt. Lacklan.	H. T. Colebrooke, Esq. F.G.S.
16.	Coal shale with impressions of leaves, from the Hawkesbury River, New South Wales.	Prof. Buckland, F.G.S.
	Fossil palate of a fish from a gravel-pit near Hedingham Castle, Essex.	Ashhurst Majendie, Esq. F.G.S.
	Specimens of limestone from Sausset, Department of Allier, France, and Cotehele, Cornwall.	T. R. Underwood, Esq. F.G.S.
	Chalcedony in chalk flint from the neighbourhood of Hemel Hemstead.	H. C. White, Esq. F.G.S.
21.	Impression of a leaf in coal shale from Welbach Colliery near Shrewsbury.	A. Aikin, Esq. V.P.G.S.
Feb. 3.	Stone from Godstone, with an analysis.	Rev. J. Holme, F.G.S.
10.	Fragment of the upright stone in Rudstone churchyard, near Bridlington, Yorkshire.	W. C. Trevelyan, Esq. F.G.S.
	Prehnite with part of the matrix from Boltallack, Cornwall.	A. Majendie, Esq. F.G.S.
Mar. 2.	Specimens from the diluvial gravel at Abingdon.	Prof. Buckland, Pres. G.S.
	Fossils from the Stonesfield slate.	C. Lyell, Esq. Sec. G.S.
	Specimens from Islay, Tiree and Jura.	Capt. Vetch, F.G.S.
	Specimens from India, collected by Capt. Lacklan.	H.J.Colebrooke,Esq.F.G.S.
11.	Orthoceratite in limestone.	H. C. White, Esq. F.G.S.
	Specimens from North America.	G. B. Greenough, Esq. V.P.G.S.
15.	Rocks from Cornwall.	Rev. John Rogers.
	Fossils from a gravel-pit, Castle Hedingham, Essex.	A. Majendie, Esq. F.G.S.
19.	Impression of a plant in coal shale.	Mrs. Governor King.
	Impressions of plants from the coal measures near Sheffield.	F. Chantrey, Esq. F.G.S.
	Fossils from the Orkney Islands.	Capt. Vetch, F.G.S.
	Specimens from Van Dieman's Land and New South Wales.	Rev. H. Scott, F.G.S.
April 1.	Wood from the moss of Auldgursack, Aberdeenshire.	D. Gordon, Esq. of Abergeldie.
	Fossil plants from the Sheffield coal-field.	F. Chantrey, Esq. F.G.S.
4.	Fossils from the chalk and green sand.	Miss Benett.
	Trachyte and other rocks from the Ponza Islands.	G. P. Scrope, Esq. F.G.S.
	Various rocks from the Island of Ischia and the Phlegrean field near Naples.	
	Specimens from Labrador.	C. Lyell, Esq., Sec. G.S.
	Specimens from the environs of Rome.	A. Majendie, Esq. F.G.S.
	Titanium in slag, from the Cyfartha Iron Works at Merthyr Tydvil.	L. W. Dillwyn, Esq. Hon. M.G.S.

List of Donations.

1824.		SPECIMENS.	DONORS.
April	8.	Chalcedony in chalk flints from the neighbourhood of Hemel Hemstead.	H. C. White, Esq. F.G.S.
		Fossils from the Dublin limestone.	Hon. Geo. Knox, F.G.S.
	24.	Fossil shell from the Oxford clay, and a pebble from the diluvial gravel, Oxford.	Prof. Buckland, Pres. G.S.
	26.	Specimens of the rock of Cerigo, and of the principal mountain chain of Cephalonia.	Sir H. Bunbury, Bt. F.G.S.
May	1.	Simple minerals and rocks, collected on the shores of South America and Mexico.	Capt. Basil Hall, R.N. F.G.S.
	5.	Fossil bones found in the fissures of a sandstone rock at the Hinck's Hay near the Old Park Iron Works, Dawley, Shropshire.	Thos. Botfield, Esq. F.G.S.
		Eschara foliacea from Weymouth.	Miss Benett.
	8.	Specimen of a Mya from diluvial clay at Ilford in Essex, containing bones of the Elephant, Rhinoceros, &c.	John Gibson, Esq. F.G.S.
		Fossil jaw in gypsum from the Paris Basin.	E.W. Rundell, Esq. F.G.S.
		Specimens collected on a journey through the Province of Khoras an in Persia.	J. B. Frazer, Esq. F.G.S.
		Fossil shells from Hordwell Cliff.	Miss Salisbury.
		Specimens of the lead strata in the district of Alston, with a printed reference by Westgarth Forster, Esq.	Rev. J. H. Scott, F.G.S.
		Specimens of the strata in the Hetton Colliery, Durham.	.....
	20.	Specimens of rocks from Ceylon.	T. D'Oyley, Esq.
		Aphrodita aculeata and two Astreæ from Swansea.	Miss Benett.
June	6.	Specimens from New South Wales.	T. Hoblyn, Esq.
	10.	Specimens from Madeira.	J. E. Bowdich, Esq.
		Specimens from the Arctic Seas, collected in Capt. Parry's second voyage.	C. Stokes, Esq. F.G.S.
	29.	Impressions of vegetables in coal shale, Radstock.	Hon. W. Waldegrave, Capt. R.N.
		Impressions of vegetables from near Hemsford and Bradford, Doncaster.	Rev. R. B. Cooke, F.G.S.
		Magnesian limestone from Mansfield, Nottinghamshire.	A. Aikin, Esq. V.P.G.S.
		Specimens from Van Dieman's Land.	E. Barnard, Esq.
Oct.	22.	Impressions of vegetables in coal shale, from Camerton near Bath.	A. B. Lambert, Esq. F.G.S.
		Sulphuret of silver from St. Ynes-mine in the Real del Monte, Mexico.	J. Taylor, Esq. Treas. G.S.
Nov.	5.	Fossils from the Isle of Purbeck.	W.H. Fitton, M.D. V.P.G.S.
		Minerals from the North Seas.	Sir John Franklin, Capt. R.N. F.G.S.
		Specimens from the beds below the chalk in the Isle of Wight.	T. Webster, Esq. Sec. G.S.
		Specimens of the beds and fossils in the Isle of Portland.	.....
	19.	Gryphæa incurva, found in the lias upon the red stone in which the Copper Works of Chessy are situated.	J. B. Pentland, Esq.
		Specimen of a lately discovered ore of lead from a cross vein in Huel Alfred Mine, Cornwall.	J. Taylor, Esq. Treas. G.S.

List of Donations.

1824.		SPECIMENS.	DONORS.
Nov.	29.	Specimens of the rock of the Isle of St. Kilda, Hebrides.	W. Bullock, Esq. F.G.S.
		Two Elephant's teeth from Cape Coast Castle.	S. Turner, Esq. F.G.S.
Dec.	1.	Various specimens of the oolitic series of Oxfordshire.	C. Lyell, Esq. Sec. G.S.
	2.	Specimens from the Cape of Good Hope.	Major Colebrooke.
	16.	Freshwater rock-marl, and recent shells from the county of Forfar.	C. Lyell, Esq. Sec. G.S.
		Specimens of English rocks.	Prof. Buckland, Pres. G.S.
	31.	Ironstone and limestone from New South Wales.	Barron Field, Esq.
1825.			
Jan.	12.	Specimens of rocks from Sardinia and some of the neighbouring islands.	C. Lyell, Esq. Sec. G.S.
	14.	Specimens from Newfoundland and the Coast of Labrador.	R. Morrison, Esq. R.N.
	21.	Specimens of rocks and fossils from Lake Huron and the Falls of Niagara.	Sir H. Davy, Bart.
		Simple minerals.	Sir A. Crichton, V.P.G.S.
		Specimens of marl and of the shells found in it, from near Romsey.	C. Lyell, Esq. Sec. G.S.
	28.	Specimens from the gravel on the red marl in the midland counties.	Rev. J. Yates, F.G.S.
Feb.	8.	Fossils from the gault at Barham Parsonage on the Medway.	H. Warburton, Esq. V.P. G.S.
		Fossil bones of the crocodile from the London clay.	J. Parkinson, Esq. F.G.S.
		Fossil bones of the crocodile from the London clay.	G. B. Greenough, Esq. F.G.S.
	18.	Encrinites Moniliformis.	Sir A. Crichton, V.P.G.S.
		Two casts of a large Trilobite, one fragment of the same Trilobite, and two small bivalves from Trenton, New Jersey.	Dr. Wollaston, F.G.S.
		Anthracite from the Lehigh River, New York.	.....
		Fossil bivalve, Lockport, New York.	.....
		Specimen of a breccia resembling that of Gibraltar, found in a fissure in the limestone rock at Chudleigh.	Prof. Buckland, Pres. G.S.
	20.	Fossils from the Dudley limestone and coal shale.	Joseph Payton, Esq.
		Specimens of transition limestone from Nether Stowey.	Prof. Buckland, Pres. G.S.
		Recent shells from the Bermudas.	Edward Belcher, Esq. Capt. R.N. F.G.S.
Mar.	6.	Specimens from the vitrified fort, Craig Phadric, near Inverness, and a specimen from the basaltic columns at Ulva in the Hebrides.	Dr. Bostock, V.P.G.S.
	18.	Specimens from the Brora coal-field, Sutherlandshire.	C. Lyell, Esq. Sec. G.S.
		Chalk flints from Aberdeenshire.	.....
	19.	Specimens of the rock from Guadeloupe, in which the human skeleton (now at the British Museum) is imbedded.	C. König, Esq.
		Fossils from the tertiary formations near Piacenza and Monte Pelegrino, near Palermo.	J. F. W. Herschel, Esq. F.G.S.
April	9.	Simple minerals from North America.	Dr. S. Fowler.
		Specimens from India, collected by the late Dr. Voysey.	Annesley Voysey, Esq.

List of Donations.

1825.		SPECIMENS.	DONORS.
May	1.	Series of rocks from the lead mining country of Cross Fell in Cumberland and Northumberland, collected by Westgarth Forster, Esq.	Sir Charles Monck, Bart. M.P.
		Fossils from the chalk at Lewes.	Gideon Mantell, Esq. F.G.S.
		Specimens of serpentine and sandstone from Forfarshire.	C. Lyell, Esq. Sec. G.S.
		Fossil wood and rocks bored by a Pholas.	W. Bullock, Esq. F.G.S.
		Specimens from the Vicentine, Hungary, the Basin of Vienna, and Auvergne.	Dr. Daubeny, F.G.S.
	18.	Serpentine from Portsoy.	C. Lyell, Esq. Sec. G.S.
		Elvan porphyry from Cornwall.	.....
		Serpentine, greenstone, and diallage rock, from Cornwall.	.....
		Specimens from Predazzo in the Tyrol.	J. F. W. Herschel, Esq. F.G.S.
		Specimens from Predazzo in the Tyrol.	G. P. Scrope, Esq. F.G.S.
	20.	Green carbonate of copper, occurring in the magnesian limestone, at Newton Kime, near Tadcaster, Yorkshire.	W. Marshall, Esq. F.G.S.
		Granite from Salun, Massachusetts, North America.	S. Dexter, Esq.
		Grey cobalt containing 11 per cent of zaffre, from Black Combe, Cumberland.	Rev. J. Holme, F.G.S.
		Specimens from Clunie, Perthshire.	C. Lyell, Esq. Sec. G.S.
		Wood from the Cape of Good Hope, collected by Major Colebrooke.	H. T. Colebrooke, Esq. F.G.S.
		Specimens from the neighbourhood of Beer in Devonshire.	J. Woods, Esq. F.G.S.
June	3.	Specimens from the tertiary beds near Paris.	C. Lyell, Esq. Sec. G.S.
July	2.	Rocks from North America.	The Hon. S. von Rensellaer.
		Plaster casts of fossil bones from Tilgate Forest.	G. Mantell, Esq. F.G.S.
		Specimens from North America.	T. Mead, Esq. F.G.S.
Nov.	3.	Specimens from New Holland and New South Wales.	Capt. King, R.N.
		Granite with green felspar, found in excavating at Tivoli.	Rt. Hon. Lord Compton, F.G.S.
	17.	Specimens from the Himalaya Mountains, East Indies.	H. T. Colebrooke, Esq. F.G.S.
		Ammonites from the southern face of the Máná Pass in the Himalaya Mountains, found in the bed of a torrent 17,000 feet above the sea.	.....
		Fossil bones from the Crest of the Nítí Pass in the Himalaya Mountains, 17,000 feet above the sea.	.....
	18.	Specimens from Jamaica.	H. T. De la Beche, Esq. F.G.S.
	25.	Copy of a cast of the animal of Maestricht in the possession of T. Allan, Esq. of Edinburgh.	Dr. Buckland, Pres. G.S
		Sandstone inclosed in a mass of columnar basalt from Badingen in the Vogelsgebirge, N.E. of Frankfort on the Maine.	Dr. Daubeny, F.G.S.
Dec.	2.	Specimens of the anthracite-coal-formation, Pennsylvania.	J. Cist, Esq.
	7.	Specimens from Radnorshire.	Frankland Lewis, Esq.
		Rocks and minerals found at Hyderabad.	Capt. Wallis, M.N.I.
		Silicified vertebra from Taman, on the shores of the Cimmerian Bosphorus.	G. P. Scrope, Esq. Sec. G.S.
		Various rocks and minerals.	A. Majendie, Esq. F.G.S.

List of Donations.

1825.	SPECIMENS.	DONORS.
Dec. 7.	Specimens from North America.	W.Maclure,Esq.For.M.G.S.
	Recent shells.	Miss Benett.
	Specimens of the green sand and of the Weald in Sussex and Hants, to illustrate a memoir by R. I. Murchison, Esq. Sec. G.S. F.R.S.	R. I. Murchison, Esq. Sec. G.S.
28.	Specimens from the Duchy of Nassau.	Sir A. Crichton, V.P.G.S.
	Rocks and fossils from Sutherlandshire.	M. Culley, Esq. F.G.S.
1826.		
Jan. 7.	Native sulphate of soda and gypsum impregnated with it, from Muligru in Argovia.	Signor Carlos de Gimbernat, For. M.G.S.
	Portion of a diseased tusk of an Elephant.	W. H. Pepys, Esq. F.G.S.
	Fossils from Lake Huron, North America.	Lieut. Bayfield, R.N.
25.	Specimens of part of the Oolite Series.	C. Bathurst, Esq.
Feb. 3.	Fossils from the mountain limestone.	Cooper Preston, Esq.
15.	Fossil coral from Harmony, North America.	Arthur Aikin, Esq. F.G.S.
17.	Bones from Kent's Hole, Torquay.	Mrs. Cazalet.
	Fossils from Lake Huron.	H.Warburton,Esq.V.P.G.S.
	White tin ore from St. Agnes, Cornwall.	JohnTaylor,Esq.Treas.G.S.
	Specimens from Pool Bay and Studland Bay.	C. Lyell, Esq. Sec. G.S.
Mar. 24.	Specimens of coal from South Wales.	L.W. Dillwyn, Esq. Hon. M.G.S.
April 21.	Rocks from Radnorshire.	Frankland Lewis, Esq.
	Silicified wood from Montserrat.	G. P. Scrope, Esq. F.G.S.
22.	Limestone, found in the county of Argyle, N.S.Wales.	Rev. Archdeacon Scott, F.G.S.
May 5.	Pecten Hoeninghausii (Defrance) from the alluvium of Kleyen Spouwen, near Tongres.	M. F. G. Hoeninghaus.
	Otion Cuvieri, Cineras vittata, and Lepas anatifera, from St. Michaels.	Miss Benett.
	Anodonta Cygneus, Longleat, Wilts.	.....
	Rocks from North America.	Lieut. Portlock, R.E. F.G.S.
19.	Fossil crustacea, Speeton Cliff, Yorkshire.	Cooper Preston, Esq.
	Fossils from the shale of the mountain limestone at Rylstone, Yorkshire.	.....
	Productus from the magnesian limestone near Ripon, Yorkshire.	.....
	Specimens from a well, sunk in the London clay.	C. Stokes, Esq. F.G.S.
June 12.	Various rocks and simple minerals from Ceylon and the Red Sea.	Capt. Pringle, R.E. F.G.S.
	Specimens from Cader Idris, North Wales.	Arthur Aikin, Esq. F.G.S
July 16.	Tin ore as taken from the mine, Great Carimon Island, Straits of Sincapore.	JohnTaylor,Esq.Treas.G.S.
Sept. 3.	Specimens of grauwacke with fossil shells from the summit of Snowdon.	E. W. Head, Esq. F.G.S.
Oct. 8.	Specimens of North American minerals.	Dr. Hossack.
12.	Sulphate of barytes with crystallized quartz in the interior, from the Fuller's-earth at Nutfield.	H. Warburton, Esq. F.G.S.
	Plaster cast of the tooth of the Ursus cultridens from Kent's Hole.	Rev. J. M'Enery, F.G.S.

1826.		SPECIMENS.	DONORS.
Nov.	11.	Specimens of sandstone from Madeira.	Rev. J. Bulwer.
	17.	Fossils from the Plymouth limestone.	Rev. R. Hennah, F.G.S.
		Fossil fish from Monte Bolca.	John Broster, Esq.
		Fossil shark's teeth from Gozo near Malta.	Lieut.Gen. Sir Rufane Donkin, G.C.H. K.C.B. F.G.S.
Dec.	1.	Specimens from Van Dieman's Land.	W. Bedford, Esq.
		Impression of a vegetable stem on sandstone from the gritstone quarries at Wickersley, near Rotherham.	
	8.	Three specimens of rocks, and recent shells.	Capt. Kater, F.R.S.
		Tooth of the Mammoth from the Banks of the Ocker near its junction with the Volga.	G.B.Greenough, Esq. F.G.S.
		Fossils from the vicinity of the Gitimer in Volhynia.	Sir A. Crichton, V.P.G.S.
		Four casts of shells from St. Mary, Jamaica.	.....
	15.	Heads, stems, and various parts of Crinoidea, from Lancashire.	.....
		Specimens from Sussex.	W. Gilbertson, Esq.
		Fossil fish from the copper-slate of Thuringia.	G. Mantell, Esq. F.G.S.
			C. Stokes, Esq. F.G.S.
1827.			
Jan.	5.	Cast of an Ammonite from the oolitic series.	C. Bathurst, Esq.
		A supposed Ophiolite.	M. Stift, Gen. Superint^{t} of the Mines of Nassau.
	6.	Fossils from the rock above the Fuller's-earth at Nutfield.	C. Bathurst, Esq.
	10.	Mill-stone grit, containing small fragments of garnets.	W. C. Trevelyan, Esq. F.G.S.
Mar.	2.	Volcanic rocks from Auvergne.	G. P. Scrope, Esq. F.G.S.
		Rocks and fossil shells from the N.E. and N.W. coasts of Scotland, in illustration of a memoir upon the Brora Coal-field by R. I. Murchison, Esq. Sec. G.S. F.R.S.	R. I. Murchison, Esq. Sec. G.S.
		Rocks and fossil shells from the Scarborough coast.	.....
		Fossil fish from Banniskirk, Caithness.	.....
April	6.	Fossil coral from Torquay.	H. J. Brooke, Esq. F.G.S.
		Echini from the chalk.	R. Heathfield, Esq. F.G.S.
		Recent and fossil corals from Torquay.	Mrs. Cazalet.
		Bovey coal.	.....
	20.	Specimens from the Whin Dyke in Cowpen Colliery, near Blyth in Northumberland.	W. C. Trevelyan, Esq. F.G.S.
		Apennine limestone from near Placentia.	Dr. Buckland, V.P.G.S.
		Portion of a large head of the Ichthyosaurus platyodon.	H. T. DelaBeche, Esq. F.G.S.
June	1.	Fossil bones of the Hyæna and other animals, found in a cave near Maidstone.	J. Braddick, Esq
	15.	Fossils from the sandstone of Parham Park and Pulborough Mount.	G. P. Martin, Esq.
July	9.	A legacy of recent shells, fossils, and minerals.	The late Capt. Apsley, F.G.S.
Aug.	11.	Recent shells from the neighbourhood of Rome.	Dr. Leach.
Oct.	27.	Peacock coal from Abersychan, South Wales.	S. Taylor, Esq. Jun.
Nov.	1.	Fossil fish from Troup Head, Banff.	A. Murray, Esq.
	2.	Silicified fir-wood from Van Dieman's Land.	C. Stokes, Esq. F.G.S.
		Jacotinga, or iron ore, in which the gold is found at the Mine of Gongo Soco in Brazil.	I. L. Goldsmid, Esq. F.G.S.

1827.		SPECIMENS.	DONORS.
Nov.	2.	Recent limestone from the beach on the coast of Karamania.	Capt. Beaufort, R.N.
	12.	Specimens from Sweden and Norway.	R. Allan, Esq. F.G.S.
	15.	Additional fossils of the oolitic series in Scotland.	Prof. Sedgwick, V.P.G.S. and R. I. Murchison, Esq. Sec.G.S.
		Specimens of the upper bed of the Brora coal, composed entirely of the plant Oncylogonatum carbonarium.	R. I. Murchison, Esq. Sec. G.S.
		Recent fluviatile shells from Little Brandon, Norfolk.	R. C. Taylor, Esq. F.G.S.
Dec.	20.	Specimens from Van Dieman's Land, Madagascar, &c.	J. Sibbald, M.D.
		Specimens from Anglesea and the neighbourhood of Snowdon.	A. Majendie, Esq. F.G.S.
	21.	Ammonite from the Isle of Man.	Col. Wilks, F.G.S.
1828.			
Jan.	4.	Specimens of fossil vegetables from the Northumberland and Durham Coal-field.	W. Hutton, Esq. F.G.S.
		Specimen of the rock from the surface of Braambury Hill, Sutherland, showing marks of denudation.	R. I. Murchison, Esq. Sec. G.S.
	15.	Bones from the Bramerton Crag; and Terebratulæ in flint, from Norwich.	S. Woodward, Esq.
		Specimens to illustrate a memoir on the secondary strata of the Isle of Arran, by Professor Sedgwick, V.P.G.S. F.R.S. and R. I. Murchison, Esq. Sec. G.S. F.R.S.	Professor Sedgwick, V.P. G.S. and R.I.Murchison, Esq. Sec.G.S.
	26.	Porphyry from Symond's Bath, Exmoor Forest.	A. Majendie, Esq. F.G.S.
		Fossil bones, wood, and shells, from Ava.	John Crawford, Esq. F.G.S.
	30.	Specimens from the lower green sand near Seven Oaks, Kent.	Rev. J. H. Randolph, F.G.S.
		Specimens of rocks from Spitzbergen, obtained during the expedition to the North in the year 1827.	Sir W. Parry, Capt. R.N. F.G.S.
		Fossils from Spitzbergen, obtained during the expedition to the North in the year 1827.	Capt. Foster, R.N. F.G.S.
		A series of specimens collected during the expedition to the N.W. coast of America in the years 1826–1827.	Sir John Franklin, Capt. R.N. F.G.S. and D. Richardson, Esq. M.D. F.R.S.
Feb.	29.	Specimens of chromate of iron from Pennsylvania.	Leonard Cox, Esq.
Mar.	20.	A pair of antlers of the Irish stag.	Rev. W. Buckland, D.D. F.G.S.
		Modern columnar lava from the Coulée of Jaujac at the bridge of Naigle, Ardeche.	.....
	21.	Specimens from the Straits of Magellan.	— Bowen, Esq.
		Fossils from the London clay at Highgate.	G. B. Snow, Esq. F.G.S.
		Tooth of the Mammoth, from the Kensington Canal, near the Hammersmith road.	John White, Esq. through H. C. White, Esq. F.G.S.
April	7.	Fossil bones from the Caverns of Echenoz, near Vesoul.	J. B. Pentland, Esq.
		Casts of fossil bones, of the Paris Basin.	Baron Cuvier, For. M.G.S.
	29.	Specimens from the vicinity of Christiana.	M. Otto Tank of Rod.
May	1.	Specimens from the River Columbia, N.W. coast of America.	A. Douglas, Esq.

List of Donations.

1828.		SPECIMENS.	DONORS.
May	1.	Fossil Nautilus from Sheppy.	Mrs. Twopenny of Rochester.
		Specimens from the neighbourhood of Brentford.	Rev. J. H. Randolph, F.G.S.
	13.	Collection of fossil bones from the diluvium near Brentford.	.....
		Fossils from the mountain limestone at Closeburn, Dumfriesshire.	J. S. Menteith, Esq.
		Suite of rocks and organic remains from the North of Scotland, to illustrate a memoir by Prof. Sedgwick, V.P.G.S. F.R.S. and Roderick Impey Murchison, Esq. Sec. G.S. F.R.S.	Prof. Sedgwick, V.P.G.S. and R. I. Murchison, Esq. Sec. G.S.
	16.	A specimen of Blitzröhre, or sand cemented by the effect of lightning, from the Senner Heath.	Dr. Fiedler.
	21.	Specimens from the Island of St. Peter and St. Paul, Bahia, Fernando, Norouha, and Pernambuco.	J. Parkinson, Esq. F.G.S. Consul at Pernambuco.
June	10.	Two specimens from Tyne-Bottom-limestone, Rowgill, near Alston, Cumberland; and one from a bed of conglomerate in diluvium, near Mitford in Northumberland.	W. C. Trevelyan, Esq. F.G.S.
Sept.	12.	Specimen of Ichthyosaurus intermedius from Lyme Regis.	H. T. De la Beche, Esq. F.G.S.
Oct.	4.	Fossil plants in coal shale from Merthyr Tydvil.	C. Stokes, Esq. F.G.S.
Nov.	5.	Organic remains found in digging the New Basin of the London Docks.	H. Palmer, Esq. Engineer to the London Docks.
		Specimens of rocks, fossils, &c.	Sir A. Crichton, M.D. F.G.S.
	21.	A Turrilite from Eastbourne.	J. E. Lushington, Esq., through Dr. Wollaston, V.P.G.S.
Dec.	5.	Specimens to illustrate a memoir on the volcanic districts of Central France, by Charles Lyell, Esq. For. Sec. G.S. F.R.S. and Roderick Impey Murchison, Esq. Sec. G.S. F.R.S.	C. Lyell, Esq. For. Sec. G.S. and R. I. Murchison, Esq. Sec. G.S.
		Fossil remains of a deer and an ox, found in the gravel at Gravesend.	Earl of Darnley, and W. Gladdish, Esq. F.G.S.
		A pair of antlers of the Irish stag.	Rev. W. Buckland, D.D. F.G.S.
1829.			
Jan.	16.	Fragment of lias, with cast of an Ammonite from the gravel at Muswell Hill, Middlesex.	G. B. Snow, Esq. F.G.S.
Feb.	3.	Casts of Plesiosaurus Dolichodeirus, and casts of other fossil remains.	Baron Cuvier, For. M.G.S.
	20.	Specimen from the Island of Ascension.	— Barnard, Esq.
	23.	Cast of the head of the Mosasaurus.	Baron Cuvier, For. M.G.S.
Mar.	11.	Wavellite from Cork.	T. Meade, Esq. F.G.S.
	13.	Casts of bones of a fossil Crocodile.	Rev. W. Conybeare, F.G.S
	19.	Tertiary and secondary rocks and fossils from the neighbourhood of Bassano, to illustrate a memoir by Roderick Impey Murchison, Esq. Sec. G.S. F.R.S.	R. I. Murchison, Esq. Sec. G.S.

1829.	SPECIMENS.	DONORS.
April 2.	Rocks of the freshwater and volcanic formations of the Cantal, France, to illustrate a memoir by Charles Lyell, Esq. For. Sec. G.S. F.R.S. and R. I. Murchison, Esq. Sec. G.S. F.R.S.	C. Lyell, Esq. For. Sec. G.S. and R. I. Murchison, Esq. Sec. G.S.
3.	Fossil fish and rocks of Seefeld in the Tyrol, to illustrate a memoir by R. I. Murchison, Esq. Sec. G.S. F.R.S.	R. I. Murchison, Esq. Sec. G.S.
29.	Rocks from Chamouny and its environs.	J. Auldjo, Esq. F.G.S.

PLATES AND MAPS

IN ILLUSTRATION

OF

VOLUME II.

SECOND SERIES,

OF

THE TRANSACTIONS

OF

THE GEOLOGICAL SOCIETY

OF LONDON.

LONDON:

PRINTED BY RICHARD TAYLOR, RED LION COURT, FLEET STREET.

SOLD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY,
SOMERSET HOUSE.

1829.

EXPLANATION OF THE PLATES.

PLATES I. & II.

Illustrate a paper on the Geology of Southern Pembrokeshire, by H. T. De la Beche, Esq. Art. I. p. 1, &c. of the present volume.

Plate I.

A map of Southern Pembrokeshire.

Plate II.

Sections of various parts of the coast of Southern Pembrokeshire.

Fig. 1. Contortions of greywacké-strata in the proximity of trap, at the entrance of Druson Haven in St. Bride's Bay: vide pp. 6, 10, & 20.

Fig. 2. Coast-section from Broad Haven to Mill Haven in St. Bride's Bay: vide pp. 6, 7, 12, 15, & 18.

Fig. 3. Coast-section at West Angle, on the eastern side of the entrance to Milford Haven: vide page 16.

Fig. 4. Contorted strata of mountain-limestone, near Eligug Stack, on the southern coast of Pembrokeshire: vide p. 17.

Fig. 5. Vertical and contorted strata of limestone, resting upon highly inclined strata of old red sandstone, at Stackpole Quay: vide p. 17.

Fig. 6. Coast-section from Tenby to Sandersfoot, in Caermarthen Bay: see the description of the mountain-limestone at p. 15, and of the coal-measures at p. 18.

PLATES III. & IV.

Illustrate Mr. De la Beche's paper on the Lias of the coast in the vicinity of Lyme Regis. Art. II. p. 21, &c.*

* The relative position of the cliffs referred to in this paper is represented in Plate VIII. of Vol. I. (Second Series).

EXPLANATION OF THE PLATES.

Plate III.

Fig. 1. An ideal section, representing the order of the strata in the vicinity of Lyme Regis: see p. 21.

Fig. 2. View of a remarkable fault, at the bottom of Pinhay Cliff, near Lyme Regis: see p. 24, 25.

Plate IV.

Organic remains found in the lias near Lyme Regis: see p. 27, &c.

Fig. 1. A jaw, apparently of a fish: p. 27.

Fig. 2. A jaw, apparently of a fish, different from the last: p. 27.

Fig. 3. Imperfect remains of a crustaceous animal, from the cabinet of Miss Philpot of Lyme: p. 27.

Fig. 4. Orthocera elongata: see p. 28.

Fig. 5. Remains of an Echinus, from the lias-marl: see p. 28.

Fig. 6. Fossil wood: p. 29.

Fig. 7. Remains of a plant: p. 29.

PLATES V. & VI.

Illustrate Mr. Webster's paper on the Strata at Hastings. Art. III p 31:—and on the Purbeck and Portland Beds. Art. IV. p. 37.&c.

Plate V.

Elevation of the cliffs at Hastings in Sussex, from the White-rock on the west, to Cliff-end on the east. The ancient town of Hastings is situated between the West and East cliffs; the greatest part of what lies between the West-cliff and the White-rock having been built lately. On the top of West-cliff are the ruins of the Castle.

Letters of reference, placed on the cliffs, point out the details given in the paper, p. 31, et seq. At the White-rock, the mamillated calciferous sandstone is on a level with the sea at *d*: it then rises, and is seen on the top of the cliff at *d*, under the Lime-kiln; again at *g*, *g*, in East-cliff; and at *f*, *f*, at Cliff-end. The sloping surface, partly covered with grass, under this, at *e*, *e*, is the dark-coloured shale (see p. 33). The perpendicular surface at East- and West-cliff, *h*, *h*, shows the soft sandstone, in which many caves are excavated; for the fine white sand, of which the rock consists below this, is slate-clay and shale, *i*, *i*. At *k* in West-cliff, is seen the place where the latter bed was well exposed, in cutting down the cliff to build the Bazaar. *l*, *l*, in East-cliff is another bed of sandstone; and below it, at *m*, *m*, are seen the lowest strata visible, consisting of sandstone and shale, with clay-iron-stone and carbonized vegetables.

EXPLANATION OF THE PLATES.

Plate VI.

Fig. 1. represents a part of the White-rock at Hastings, where the concretionary masses of calciferous sandstone *b*, *b*, are to be seen *in situ.*

Fig. 2. exhibits some of these masses *a*, *a*, fallen down at East-cliff: *c* shows the appearance of the rocks when they are worn by the sea after falling.

Fig. 5, 6, 7, 8, 9, 10, 11. represent organic remains found at Hastings, and described in p. 35.

Fig. 3. Section of the strata in the N.-E. end, and upper part of the Isle of Portland, in illustration of Art. IV. p. 37.

Fig. 4. Fossil wood, the situation of which is represented in *fig.* 3.—on a larger scale.

PLATES VII. VIII. & IX.

Illustrate Mr. Miller's paper on Belemnites. Art. V. p. 44. &c.:—and on the Genus Actinocamax. Art. VI. p. 63, &c.

Plate VII.

Fig. 1. The conical chambered shell of the Belemnite taken out of the guard.—The figure represents the external slightly rugged shell, to which the laminæ of the guard adhere; also the probable depth of the outer chamber, with the aperture of the siphunculus: see p. 50, &c.

Fig. 2. Section to show the form of the siphunculus in the conic-chambered shell.

Fig. 3. Section to show the chambers, which are filled with calcareous spar.

Fig. 4. A magnified representation of the section of the siphunculus, showing its laminar structure, and its adhesion to the external conic shell.

Fig. 5. A magnified representation of the transverse septa in the chambered cone, showing their laminar structure, and their adhesion in common to the shell.

Fig. 6. Belemnites elongatus (see p. 60.), taken from two portions in Mr. Miller's collection, one of which, as here represented, shows the projecting of the chambered shell beyond the guard, and the depth of its outer chamber. The dotted line marks the space occupied by the cone.

Fig. 7. A longitudinal section of Belemnites elongatus, showing the laminar structure of the guard, and the chambered cone in part surrounded by its shell *in loco:* p. 60.

Fig. 8. A transverse section of B. elongatus, with a concave septum belonging to the chambered cone in the centre: p. 60.

Fig. 9. Belemnites abbreviatus: see p. 59.

Fig. 10. Transverse section of B. abbreviatus, with a concave septum in the centre, belonging to the chambered cone: p. 59.

EXPLANATION OF THE PLATES.

Plate VIII.

Fig. 1. Belemnites longissimus: p. 60.

Fig. 2. Transverse section of the guard of the same: p. 60.

Fig. 3. Belemnites sulcatus: see p. 59.

Fig. 4. Transverse section of its guard, showing in the centre its nearly circular outline: p. 59.

Fig. 5. A variety of Belemnites sulcatus, showing the abbreviated laminæ as they form the longitudinal groove: p. 59.

Fig. 6. Belemnites aduncatus: p. 59.

Fig. 7. The apex of the same: p. 59.

Fig. 8. Transverse section of the guard: p 59.

Fig. 9. Belemnites acutus: p. 60.

Figs. 10 & 11. Belemnites tripartitus;—a front and back view: p. 60.

Fig. 12. Transverse section of B. tripartitus, showing the guard formed of three longitudinal portions: p. 60.

Fig. 13. Transverse section of B. tripartitus, near the apex of the guard: p. 60.

Figs. 14 & 15. Belemnites ellipticus, from Dundry: these two parts fit together: p. 60.

Fig. 16. Transverse section of B. ellipticus: p. 60.

Fig. 17. Belemnites ellipticus, var. *α*.

Fig. 18. Belemnites electrinus: p. 61.

Figs. 19 & 20. The two longitudinal portions, forming the guard of the Belemnites electrinus (see p. 61.); showing in the centre the canal formed by decomposition, and at the apex of *fig.* 19 the mamillated and conical point,—separated from *fig.* 20,—in which last figure there has been left a corresponding cavity, which, when found separate, led to the erroneous notion of the Belemnite having two conic chambered shells.

Fig. 21. Outline of the impression of the blood-vessels on the guard of Belemnites electrinus: p. 61.

Fig. 22. Belemnites fusiformis: p. 61.

Plate IX.

Fig. 1. Fragments of B. electrinus (p. 61), showing an induration formed in the canal resulting from decomposition, and exposed by the separating and falling out of a portion of the laminæ forming the guard.—This appearance occasioned the erroneous impression that the Belemnite had a canal extending from the siphunculus through the guard; the projecting point being considered as having been formed in the siphunculus.

Fig. 2. Magnified representation of 2 nacrous laminæ, having crystalline spiculæ pro-

jecting from them, and showing near the apex the accumulated nacrous matter, which on decomposition formed the canal.

Fig. 3. Illustrative views of fragments of Belemnites electrinus (see Pl. VIII. figs. 18, 19, 20.) as found in Prussia, their cylindrical form arising from wearing down by attrition before they were imbedded in the sands in that country.

Fig. 4. Pyritic cast of the chambered cone, showing the indentures formed by the decomposition of the siphunculus, which cavities have been erroneously considered as spiraculæ.

Fig. 5. Transverse section of Belemnites fusiformis : p. 61.

Fig. 6. Belemnites minimus : p. 62.

Fig. 7. Illustrative views of the manner in which the laminæ that form the guard of Belemnites fusiformis are arranged : p. 61.

Fig. 8. Siliceous infiltrations in a portion of the guard of Belemnites ellipticus : p 60.

Fig. 9. Casts in the conic cavity formed by the dropping out of the chambered shell ; and in the grooves made by decomposition of a portion of the nacrous matter that cements the two longitudinal halves together, as also in the central canal formed by decomposition.—Casts of this description led to the theory that the supposed central canal, extending from the siphunculus through the guard, divided into two, which probably were nerves.

Fig. 10. Belemnites minimus (see p. 55 & p. 62.) corroded, and converted into silex. In the collection of Miss Benett, Norton-house, Wilts.

Figs. 11, 12, 13. Appearance of decomposition, which has acted on the apex of a Belemnite. This misled De Montford, when he formed his genera Cetocis and Acamus.

Fig. 14. Sepia loligo : see p. 57, &c.

Fig. 15. As MM. Cuvier and Lamarck agree with me in considering the inhabitant of the Belemnite to have been a Sepia, I venture here to represent a Sepia resembling loligo, but capable, on account of an abbreviated body, of insertion in the outer chamber, whilst its muscles clasped the Belemnite, denoted by dots.

Fig. 16. Spirula fragilis and its inhabitant : see p. 57.

Fig. 17. Actinocamax verus : see Art. VI. p. 64.

Fig. 18. Section of A. verus.

PLATES X. XI. XII. & XIII.

Illustrate Mr. Lyell's paper on a recent Formation of Limestone in Forfarshire, &c. Art. VIII. p. 73.

Plate X.

Fig. 1. represents a section of the strata of part of Forfarshire, from the Grampians on the north, to Dundee on the south, and shows the general structure of the country between the Grampians and the Firth of Tay : see p. 73.

This line of section (the course of which is expressed in the map, Plate XI.)

passes through the Bakie Loch, showing that the recent deposits of marl in that lake rest upon the diluvium of Strathmore.

Fig. 2. represents a canoe, found in peat overlying this marl in the Loch of Kinnordy,—a lake about 6 miles N.E. of the Bakie: see note, p. 87.—and for the deposits in that lake, p. 86.

Fig. 3. Supposed section of the deposits in the Bakie Loch: for a description of these, and of the organic remains contained in them, &c. see pp. 74, 76, 77, 79, 81, 83. and Appendix I.

Plate XI.

A map of that part of Forfarshire, in which the principal deposits of shell-marl are situated; showing that this marl is confined to the old red-sandstone formation, and the series of inferior gray, micaceous sandstone, shales, &c., with their associated trap-rocks: see p. 1 and 79.

Plate XII.

Recent and fossilized Charæ; from the Bakie Loch and other marl-lakes in the county of Forfar.

Fig. 1. *a.* Gyrogonite, or fossilized pericarpium of Chara, found in the tufaceous limestone or rock-marl of the Bakie Loch—of the natural size: p. 79, 91.

b. The same magnified 20 diameters, the upper end being placed downwards. It consists in general of the empty integument completely replaced by carbonate of lime: p. 92.

c. Lower end of ditto, to which the stem was attached: p. 92.

d. Upper end of ditto, to which the stigmata were attached.

e. Nut, sometimes found within the integument *b*; but consisting of an unfossilized brown membrane: the end to which the stigmata were attached placed downward. The small fibres appended may be the styles? p. 92.

f. represents the nut, within a portion of the fossilized integument: p. 92.

g. One of the spiral valves of *b*. These are easily separable in the Bakie Gyrogonite, as in those found in the ancient freshwater-formation: p. 92.

h. View of the interior of *d*.

i. Section of one of the valves of the integument, showing their quadrangular form: p. 91.

k. Fossilized branch of same Chara, natural size.

l. Fossilized stem of ditto, spirally striated. The striæ wind round in a contrary direction to those of the pericarpium.

m. Ditto magnified, showing it to be composed of a large tube surrounded by smaller tubes: p. 91.

Fig. 2. *a.* Pericarpium or seed-vessel of recent Chara hispida, from the Bakie Loch: of the natural size: see p. 92.

b. Integument of ditto, magnified 20 diameters, of the same species as that fossilized in Bakie (represented in *b. Fig.* 1.), but smaller, as being less ripe. Each of the five spiral valves turn rather more than twice round the circumference; the whole together making between 10 and 11 rings: p. 91.

c. Nut within ditto, the end to which the stigmata were attached placed downwards: p. 91.

d. Inferior part of the nut *c*: p. 91.

e. Superior of ditto: p. 91.

f. Stem and branches of recent C. hispida.

g. Ditto magnified.

h. Section of the stem; the smaller tubes are irregular in number: see p. 91.

Fig. 3. *a*. Pericarpium of recent Chara vulgaris; from the Bakie Loch. The stems only of this species have been found fossilized in the rock-marl: p. 93.

b. Ditto, magnified 20 diameters: p. 93.

c. Nut within the integument *b*, the end to which the stigmata were attached placed downwards: p. 93.

d. End of the nut *c*, to which the stem was attached: p. 93.

e. End of ditto, to which the stigmata were attached.

f. Stem and branch of C. vulgaris, natural size.

g. Stem and branches of ditto magnified 8 diameters.

Fig. 4. *a*. Pericarpium of a species of Chara found in many of the marl-lakes of Forfarshire, but not in the Bakie (p. 93.), the C. flexilis of Dr. Hooker's Flora Scotica.

b. Ditto magnified, and attached to the branch. The spiral valves of the integument turn each about $2\frac{1}{2}$ times round the circumference, the whole forming about 13 rings, which exceed the number in C. hispida and vulgaris, p. 93: the septa mentioned p. 91, are seen through the transparent stem.

c. Nut within ditto.

d. Branch of C. flexilis, natural size.

Fig. 5. represents a species of Helicteres, from the West Indies, of the natural size; —introduced as a subject of comparison, with the integument and nut of the pericarpium of Chara: p. 91.

Plate XIII.

Fig. 1. Chara Medicaginula, magnified 20 diameters, from the lower freshwater formation at Gurnet-bay in the Isle of Wight.

Fig. 2. *a*. The same, natural size.

b. Section of the same, magnified 20 diameters, exhibiting the nut inclosed within the integument.

c. Part of one of the spiral valves, magnified.

Figs. 3, 4, 5. Chara Medicaginula from the Isle of Wight, magnified 20 diameters. In these three specimens the number of the ribs or striæ on the nut varies from 5 to 7. Whether they should in consequence be referred to three distinct species, the present state of botanical knowledge concerning the fructification of this tribe of plants is not sufficiently advanced to determine. The nut in *figs*. 3 and 4 is perhaps partially, and that in *fig*. 5 much distorted: p. 93.

Fig. 6. Stem of Chara Medicaginula, found accompanying the preceding. It is strictly analogous to the stem of C. hispida: see Pl. XII.

EXPLANATION OF THE PLATES.

Figs. 7 & 8. Pericarpium of C. tuberculata, a new species of Gyrogonite discovered in the lower freshwater formation at White-cliff Bay, Isle of Wight. The spiral valves form constantly nine rings.—For a description of this, and of the strata in which it occurs, see p. 94.

PLATES XIV. & XV.

Illustrate Mr. Murchison's paper on the Geology of a part of Sussex, Hants, and Surrey. Art. IX. p. 97.

Plate XIV.

Geological map of the north-western part of Sussex, and the adjoining parts of Hants and Surrey; reduced from the Ordnance Map; with a section.

Plate XV.

Bones of saurian animals from the Iron-sand.

Figs. 1 to 7, from the N.E. of Loxwood: see pp. 104, 105.
Figs. 8 and 9, from Headfoldwood-common.

Fig. 1. A caudal vertebra.
2. A lumbar vertebra.
3. One of the *first* caudal vertebræ.
4. Sacrum.
5. Portion of a rib.
6. Two caudal vertebræ anchylosed together.
7. False rib; or branch of the os hyoides.
8. Vertebra found with the great femur.
9. The great femur: see p. 104.

PLATE XVI.

Detailed sections of the chalk, and sands beneath the chalk, on the coasts of Dorset and Devon, in illustration of a paper by H. T. De la Beche, Esq. Art. X. p. 109.

Fig. 1. Section to the west of Lyme Regis, Dorset: vide pp. 110—115.

Fig. 2. Section at White-cliff, to the east of Beer, Devon: vide pp. 115, 116.

Fig. 3. The same as *Fig.* 2, with some variation in the sands immediately below the chalk.

Fig. 4. Section, showing the position of the Beer-stone in Branscombe-cliffs, to the west of Beer-head: vide pp. 116, 117.

PLATE XVII.

Map of the vales of Kingsclere and Ham, to the south of Newbury, and section across the vale of Kingsclere; in illustration of a paper by the Rev. Dr. Buckland on the Formation of Valleys, &c. Art. XI. p. 119.

EXPLANATION OF THE PLATES.

PLATES XVIII. XIX. XX. XXI & XXII.

Illustrate Mr. De la Beche's paper on the Geology of Jamaica.

Plate XVIII.

A map of part of Jamaica.

Plate XIX.

Fig. 1. Section of the strata at St. George's Gap.

Fig. 2. Section from the sea near Kingston to Forster's Cove, St. Mary's.

Fig. 3. Section from Old Harbour to Luidas Vale.

Fig. 4. Section from the sea to Catherine's Peak.

Plate XX.

View of a natural bridge near Mount Olive, St. Thomas-in-the-Vale.

Plate XXI.

Represents a cast of part of a gigantic cerithium, from the yellowish white limestone.

Plate XXII.

Panoramic view from Strawberry Hill, one of the St. Andrew's Mountains.

PLATES XXIII. XXIV. & XXV.

Illustrate Mr. Scrope's paper on the Geology of the Ponza Isles.

Plate XXIII.

Map of the volcanic districts between Rome and Naples; and,

Map of the trachytic group of the Ponza Isles.

Plate XXIV.

Fig. 1. View of the Island of Ponza from the East side, about four miles distance.

Fig. 2. Semicircular cove called Chiaja di Luna, Isle of Ponza, S.W. side.

Fig. 3. Montagna della Guardia from the South.

Fig. 4. Rock of contorted and globiform pitchstone, Chiaja di Luna, Isle of Ponza.

Plate XXV.

Figs. 1, 2 & 4. Views of the eastern side of Ponza.

Fig. 3. Rock of columnar trachyte near the N. E. point of Palmarola.

Fig. 5. Zannone seen from the south.

Fig. 6. Zannone seen from the east.

Fig. 7. South-east view of Ventotiene and San Stefano.

PLATES XXVI. & XXVII.

Illustrate Mr. Yates's paper on the Structure of the Border Country of Salop and North Wales; and of some detached Groups of Transition Rocks in the Midland Counties.

Plate XXVI.

Fig. 1. Map of part of the county of Warwick, &c.

Fig. 2. Section illustrative of the same.

Fig. 3. East and west section of the Wren's Nest.

Plate XXVII.

Figs. 1 & 2. Impressions of plants, (fuci ?) from the slate-clay at Colmore's Farm, Bromsgrove Lickie.

Fig. 3. Beds of greenstone, breaking through the grauwacke at Griff Hollow, Warwickshire.

Fig. 4. Strata of quartz-rock, Bromsgrove Lickey.—A, B, highly ferruginous and micaceous shale.

PLATES XXVIII. & XXIX.

Illustrate Mr. Aikin's paper on the Geological Structure of Cader Idris.

Plate XXVIII.

The map which occupies the greater part of this Plate represents the principal features of Cader Idris and the adjacent country, copied by permission from one of the Ordnance surveys.

The winding crest of the mountain is seen stretching eastward from Barmouth Bay to the deep transverse valley of Tal y Llyn, which runs N. E. and S.W., and is the boundary of Cader Idris on that side. On the North is seen the broken ground extending to the Mawddach and its accompanying marshes, and consisting chiefly of trap rocks intermingled more or less with slate. From Mynydd pen y Caed, a little to the South of the summit of Cader Idris, begins the line of section described in Mr. Aikin's paper, which terminates North of Dalgelle, a little beyond the margin of the map.—An elevation of this section is represented in outline at the bottom of the plate.

EXPLANATION OF THE PLATES.

Plate XXIX,

Contains three geometrical elevations of Cader Idris, with the heights, in feet, above the level of the sea. The base of the North elevation is the valley of the river from Dalgelle to the sea. That of the South elevation is the valley of Tal y Llyn. That of the Section is a line running from the head of Tal y Llyn lake in a N.N.W. direction, through the summit of Cader Idris, to the river Mawddach.

PLATE XXX.

Illustrates Mr. Lyell's papers, on the Strata of the Plastic Clay Formation exhibited in the Cliffs between Christchurch Head, Hampshire, and Studland Bay, Dorsetshire; and on the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire.

Fig. 1. Section of the coast from Muddiford, Hants, to Studland Bay, Dorset.

Fig. 2. Section of the lower freshwater strata in Hordwell, Beacon and Barton, Cliffs, Hants.

PLATES XXXI. & XXXII.

Illustrate Mr. Murchison's paper on the Brora Coal-field, and some other Stratified Deposits in the North of Scotland.

Plate XXXI.

Fig. 1. A map of all that part of the S.E. coast of Sutherlandshire in which any members of the oolitic series have been traced, including the coal-field of Brora; showing also the nature of the mountain chain which bounds the Vales of Brora, Loth and Navidale.

In the lower part of the same figure is a sectional view of the coast laid down in the map.

Fig. 2. Consists of transverse sections. The first is ideal, explaining the entire order of superposition on the east coast of Sutherland, Cromarty and Ross; followed by six actual sections from the shore to the mountain chain,—of which that on the line C, D of the map particularly explains the relations of the Brora coal-field.

Fig. 3. A sectional view of part of the east coast of Ross and Cromarty, to explain the relations of the lias, as seen at low-water near Shandwick and Ethic bays. The second section from the left in *fig.* 2. relates also to this tract, showing the red conglomerate to be alone interposed between the lias and the primitive rocks.

Fig. 4. A sectional view of part of the Coast of Skye near Portree. The small valley of Beal inclosed by mountains of trap, is composed of cornbrash limestone, &c. resting upon the inferior oolite. This limestone of Beal is traversed by fissures, one of which is still occupied by compact zeolitic greenstone.

EXPLANATION OF THE PLATES.

Plate XXXII.

Fig. 1. Part of the irregularly tuberculated stem nearest to the root of oncylogonatum carbonarium.

Fig. 2. Part of the same more regularly jointed, traversing the sandstone of the eastern Moorlands of Yorkshire.

Fig. 3. Specimen of micaceous shale, representing impressions of the jointed stems of the above plant, with their grooved expansions, and of the roots,—both flattened by pressure.

Fig. 4. A portion of the bed immediately above the coal of Brora; exhibiting striated delineations similar to those of *fig.* 3.

Fig. 5. Subtriangular carbonaceous plates, occasionally found in the micaceous shale of *fig.* 3.

Fig. 6. The expansions of *fig.* 3. magnified, exhibiting the raised dots between the grooves.

PLATE XXXIII.

Illustrates Sir A. Crichton's paper on some Parts of the Taunus, &c., and represents the fossils referred to in the note at p. 268. This description is by Mr. G. B. Sowerby, F.L.S.

Fig. 1. Cast of the inside of a spirifer.

Fig. 2. This shell appears to be a Pleurobronchus of Cuvier (*Lamellaria* of Montagu) :—and in this opinion, Mr. Sowerby states, that he is confirmed by M. Heninghaus of Crefeld.

Fig. 3. Transverse section of a circular encrinital vertebra.

Fig. 4. Cast of a turbinated shell, probably a Cirrus.

Fig. 5. Spiriferæ : the same as *fig.* 1 : and cast of the inside of an undescribed hysterolite or terebratula.

Fig. 6. Transverse sections of a singular encrinital column. These sections are of a very varied figure, most of them elliptical, probably from their having been compressed in a lateral direction ; and their central perforation is pentagonal, frequently forming five stellated points.

Fig. 7. Longitudinal section of one of the same columns.

Fig. 8. Convoluted section of the same.

a. transverse section, similar to those of *fig.* 7.

Fig. 9. Longitudinal section of another species of encrinital stem.

Fig. 10. Impression of part of the stem of a reed.

Fig. 11. Jointed portion of another reed stem.

EXPLANATION OF THE PLATES.

PLATE XXXIV.

Illustrates Mr. Poulett Scrope's paper on the Volcanic District of Naples.

Fig. 2. Map of the Volcanic District of Naples.

The other figures are sufficiently explained in the paper, and in the description at the foot of each.

PLATE XXXV.

Illustrates Mr. Murchison's paper on the Strata of the Oolitic Series in Sutherland, Ross, and the Hebrides.

Fig. 1. Map of that part of the west of Scotland, and the Hebrides, in which are found the deposits of the oolitic series alluded to in the preceding Memoirs.

Fig. 2. Section on the line *a b* of the map; representing the different members of the oolitic series, in their actual order of superposition on the coast of Skye and of the adjoining Isles of Rasay, Scalpa, and Pabba. All the intrusive or overlying trap-rocks, which occur so abundantly along this line of section, are omitted; as having been completely elucidated by Dr. MacCulloch, Geol. Trans. vol. iv. page 172 et seq.

(The occurrence of a freshwater stratum overlying the oolitic series is particularly deserving of attention.)

Fig. 3. Sectional view of the south coast of Mull, on the line *c d* of the map, exhibiting the inferior oolite regularly overlying the lias at Carsaig; and the same deposits at various other places in contact with vast masses of basalt and trap, which produced considerable alteration in the characters.

PLATES XXXVI. XXXVII. XXXVIII. XXXIX. XL. XLI. XLII. XLIII. XLIV.

Illustrate Mr. Clift's paper on the Fossil Remains of two new species of Mastodon and of other Vertebrated animals, found on the left bank of the Irawadi: and Professor Buckland's Geological Account of the Animal and Vegetable Remains there found.

Plate XXXVI.

Upper jaw of Mastodon latidens (adult), showing the palate and anterior molar teeth

in situ. Parts of the broken posterior molar teeth are seen below the anterior molar teeth on either side. The plate is on the scale of half an inch to an inch.

Measurement.	Ft.	In.
Extreme length of the portion of skull	1	8
Extreme breadth of the same	1	3
Circumference of the alveolar cavity of the tusk, calculated from the remains of the cavity	1	6
Extreme length of right anterior grinder (six denticuli and the spur)	0	$8\frac{1}{4}$
Extreme breadth (at the third denticulus)	0	4
Breadth of the palate (about the middle)	0	$2\frac{6}{8}$

Plate XXXVII.

Fig. 1. The palate, and molar teeth of the right side of Mastodon latidens (a younger animal than the last). The anterior tooth is very much worn. The anterior part of the posterior tooth appears to have been just brought into use. This figure is of the natural size.

Figs. 2 to 4. Fragments of molar teeth of Mastodon latidens, showing the surfaces according to the effects of mastication; on a scale of half an inch to an inch.

Plate XXXVIII.

Fig. 1. Fragment of the anterior part of the right side of the lower jaw of Mastodon latidens seen from above. A string passed round this fragment, over the anterior part of the grinder where it is worn, measured two feet four inches. Extreme length of the tooth eleven inches and three quarters. Extreme breadth four inches and a half.

Fig. 2. Left side of the lower jaw of Mastodon elephantoides. The remains of the anterior molar tooth are seen, and behind it, the posterior tooth which was advancing, and which, in consequence of the jaw-bone being broken away, is seen through its whole length. This tooth is eleven inches long and three and a half broad. These two figures are on a scale of half an inch to an inch *.

* It may not be uninteresting to give the measurement of the molar teeth of some recent and fossil Elephants in the Museum of the College of Surgeons by way of comparison.

Recent.	Ft.	In.
African elephant. Longest grinding surface (lower jaw)	0	9
Breadth of the same	0	3
Asiatic (an old animal). Longest grinding surface (upper jaw)	0	$7\frac{1}{2}$

EXPLANATION OF THE PLATES.

Plate XXXIX.

Fig. 1. Molar milk-tooth of a Mastodon, seen from beneath.

Fig. 2. The same seen from above.

Fig. 3. A side view of the same.

Fig. 4. Part of the tusk of a Mastodon fractured transversely, showing its intersected appearance like the engine-turning of a watch-case.

Fig. 5. Symphysis of the lower jaw of a small Tapir.

Fig. 5*. End of the same, showing fragments of incisors.

Fig. 6. Upper molar tooth of Mastodon elephantoides.

All these figures are of the natural size.

Plate XL.

Fig. 1. Two molar teeth of the upper jaw of a Rhinoceros.

Fig. 2. Fragment of the lower jaw of the same animal (about the centre). Three molar teeth are shown much worn.

Fig. 3. Inside view of the posterior part of the left side of the lower jaw of a Hippopotamus.

	Ft.	In.
Breadth	0	$3\frac{1}{2}$
Lower jaw. Length	0	8
Breadth	0	$3\frac{1}{2}$
Another Asiatic (Mooknah). Length (upper jaw)	0	$8\frac{1}{4}$
Breadth	0	$3\frac{1}{2}$
Compass of one side of lower jaw of the same	2	$3\frac{1}{4}$
Compass of one side of lower jaw of another large elephant (Dauntelah)	1	$9\frac{1}{2}$
Fossil.		
Grinding surface of fossil elephant's tooth (Bridport). Length	0	8
Breadth	0	$3\frac{1}{2}$
Another, formerly in the Museum of Parkinson. Length	0	9
Breadth	0	$2\frac{5}{8}$
One from Ohio. Length	0	8
Breadth	0	$3\frac{1}{2}$
One from Siberia. Length	0	8
Breadth	0	$3\frac{1}{2}$

Fig. 4. Molar teeth of the same, broken on the outside edge, seen from above.

Fig. 5. Fragment of the lower jaw of a Hog.

Figs. 6 & 7. Molar teeth of an Ox.

Fig. 8. Molar teeth of a Deer?

All these figures are of the natural size.

Plate XLI.

Fig. 1. Lower extremity of right femur of Mastodon latidens?

	Ft.	In.
Circumference above the condyles	2	2
Circumference round the condyles	2	4
Length of the fragment	1	2

Fig. 2. Lower extremity of left femur of M. elephantoides?

Fig. 3. Condyles of the knee-joint of the same.

Fig. 4. A corresponding view of fig. 1.

Fig. 5. Upper extremity of tibia of M. latidens?

Fig. 6. Articulating surface of the same.

Fig. 7. Upper extremity of right tibia of M. elephantoides?

Fig. 8. Articulating surface of the same.

Fig. 9. Lower extremity of tibia of M. elephantoides?

Fig. 10. Articulating surface of the same.

Fig. 11. Lower extremity of fibula of Mastodon.

Fig. 12. Fragment of scapula of Mastodon latidens? showing part of the external surface.

Fig. 13. External surface of patella of Mastodon.

Fig. 14. Internal surface of the same.

Fig. 15. Lower extremity of a metatarsal or metacarpal bone of Mastodon.

Fig. 16. External surface of patella of Rhinoceros.

Fig. 17. Internal surface of the same.

Fig. 18. Upper extremity of tibia of Rhinoceros.

Figs. 19 & 20. Anterior extremity of the lower jaw of Hippopotamus (a young animal).

Figs. 21, 22, & 23. Lateral view and transverse section of the core of the horn of a large Antelope.

Figs. 24 & 25. Lateral view and transverse section of the core of the horn of a smaller animal of the same genus.

Fig. 26. Lower extremity of femur (articulating surface), Rhinoceros.

The following figures all represent the bones of Ruminants.

Fig. 27. Lower extremity of femur (articulating surface), Ox ?

Fig. 28. Lower extremity of femur (articulating surface), Ox ?

Fig. 29. Lower extremity of femur, articulating surface.

Figs. 30 & 31. Upper extremities of tibiæ.

Figs. 32 & 33. Portions of scapula, the base of the bone.—The figures in this plate are reduced one-fifth.

Plate XLII.

Represents remains of the genera Emys and Trionyx.

Figs. 1 & 2. Posterior portion of the right side of the lower jaw—Trionyx ?

Fig. 3. Internal view of a fragment of the back of a Trionyx.

Fig. 4. External view of the same.

Fig. 5. Internal view of the anterior portion of the sternum—Emys ?

Fig. 6. External view of the same.

Fig. 7. External view of a portion of the back of a Trionyx.

Fig. 8. Internal view of the same, showing the rib.

Fig. 9. External view of a portion of the back of a Trionyx.

Fig. 10. Internal view of the same.

Fig. 11. External view of a portion of the back of a Trionyx.

Fig. 12. Internal view of the same.

Fig. 13. Part of sternum of an Emys.

Figs. 14 & 15. Part of scapula of an Emys ?

Fig. 16. Part of scapula of an Emys ?

Of the bones here figured, those represented by figs. 5, 6, 14, 15, 16 have characters which justify the supposition that they belonged to the genus Emys ; but the mutilated state of the specimens prevents a satisfactory conclusion on this point. Those represented by figs. 5, 6, 16 probably belonged to the same animal, which must have been of gigantic size.

The bones represented by figs. 3, 4, 7, 8, 11, 12 evidently belonged to at least three distinct species of Trionyx. Figs. 3, 4, 7, 8 represent portions which probably belonged to the same species. In the specimen represented at fig. 11, the rugosities are unusually prominent, and distributed with very little regularity.

EXPLANATION OF THE PLATES.

Plate XLIII.

Represents the remains of Crocodilidæ.

Fig. 1. Occiput of a Crocodile.

Fig. 2. Anterior part of the lower jaw of a Crocodile.

Fig. 3. Anterior part of the right side of the lower jaw of a Crocodile.

Fig. 4. Symphysis of the lower jaw of a Leptorhynchus.

Fig. 5. Portion of the lower jaw of a Leptorhynchus.

Fig. 6. Articulation of the right side of the lower jaw of a Crocodile.

Fig. 7. Articulation of the right side of the lower jaw of a Crocodile.

Fig. 8. Osseous plate of a Crocodile, corresponding in character with those from the side of the neck in the recent Alligator. This must have belonged to an animal of enormous size.

Figs. 9, 10 & 11. Dorsal vertebræ of a Crocodile.

Fig. 12. Lower extremity of femur of a Crocodile :—from a very large animal.

PLATE XLIV.

Is a Map of that part of the Burman Empire where the remains described in the papers of Dr. Buckland and Mr. Clift, and, for the most part, figured in the foregoing plates,—were found.

PLATE XLV.

The first thirteen figures illustrate Mr. Pentland's letter on some fossil animals from Bengal. N.B. The numbers in the text do not refer to the plate.

Figs. 2, 3, 4, & 5. Portion of jaw, and teeth of *Anthracotherium Silistrense.*

Fig. 1. Posterior molar tooth of the left side of a small species of ruminant, allied to the genus Moschus.

Fig. 13. Posterior portion of the left side of the lower jaw of the same.

Fig. 7. External view of the anterior part of the right side of the lower jaw of the same.

Fig. 10. Lower extremity of the left humerus of the same.

Fig. 8. Humeral extremity of the left radius of a small species of ruminant.

Fig. 11. The first phalangal bone of the right hind leg of a small ruminant.

Fig. 12. Lower extremity of the right tibia of the same.

Fig. 6. Molar tooth of a carnivorous animal of the genus Viverra.

Fig. 9. The upper articulation of the right radius of a small species of herbivorous animal referable to the Pachydermata.

Figures 14 to 17 illustrate Mr. Stokes's notice on Echini, which will be found in the Extracts from the Minute-book at the end of the volume.

Figs. 14 & 15. Two views of Galerites albo-galerus from the chalk. In fig. 14 the plates of the mouth, consisting of five pairs, are presented *in situ*.

Fig. 16. A cidaris, also from the chalk, in which portions of the plates of the mouth and teeth are visible. They are mostly displaced, but are analogous to those found in recent species of this genus.

Fig. 17. A cidaris from Stonesfield, in which the anal plates are well shown.

PLATES XLVI. XLVII. XLVIII. XLIX.

Illustrate Professor Buckland's paper on the Cycadeoideæ, a family of fossil plants found in the oolitic series of the Isle of Portland.

Plate XLVI.

Fig. 1. Section near the base of a Cycas revoluta, in the possession of Mr. R. Brown, from a plant that died at Kew. The thinness of the outer case, composed of the bases of leaves, arises from its proximity to the root. The body of the trunk is a mass of spongy pith-like cellular tissue, in which are imbedded two laminated circles of unequal width near the centre: in the cellular tissue is much farinaceous matter.

Fig. 2. Section of Cycas circinalis or Todda Panna, copied from Pl. XXI. vol. iii. of Rheede's Hortus Malabaricus. This stem, like fig. 1, is composed of a pith-like

substance containing sago, in which seven laminated circles are disposed near the centre, with a broad ring of cellular matter exterior to the outer circle. According to this drawing, the case of the trunk has smooth rings, and is not so entirely composed of the bases of leaves and stipules as in the recent specimen of Cycas circinalis, engraved by Dr. Hooker, Pl. 2826 of Curtis's Bot. Mag. July, 1828: and as there can be no doubt of the accuracy of this plate, it is probable that in the older drawing of Rheede, this part of the structure was incorrectly represented. Dr. Hooker observes that in Richard's plate, as in that of Rheede, the stems are strongly annulated, more so than Dr. Hamilton ever saw them on the growing plant. For further details connected with this subject, see Richard's *Mémoires sur les Conifères et Cycadées;* Mr. R. Brown's Appendix to Capt. King's Narrative of a Survey of the Coast of Australia; and Curtis's Bot. Mag. No. 18 and 19, New Series, June and July, 1828.

Fig. 3, represents a section of a Zamia horrida, in the possession of Charles Stokes, Esq. made in the direction of the line A B fig. 4.

Fig. 4. Reduced representation of a living plant of Zamia horrida.

Plate XLVII.

Cycadeoidea megalophylla.—The peculiar features of this specimen have been so fully explained in the text, as to render further description needless.

Plate XLVIII.

Cycadeoidea megalophylla.—This specimen supplies the structure of important parts of the fossil Caudex, which are scarcely visible to the naked eye. The magnified appearance represented at fig. 2, is distinctly to be seen with a small lens on the parts of the laminated circle A B C, which are converted into chalcedony: where the stone is more coarse, the internal structure is less apparent.

Fig. 3, is taken from the bottom of the specimen, and shows the junction of the laminated circle with the external cellular ring and central cellular substance.

Plate XLIX.

This is the only specimen of *Cycadeoidea microphylla* which the author has seen. The transverse section is below the summit of the stem, and consequently displays no central cavity: the border of leaf-stalks surrounding the stem is much more narrow than in *Cycadeoidea megalophylla*, and the form and proportions of the plant are very different.

GEOLOGICAL MAP
of
SOUTHERN PEMBROKESHIRE.

Trap-Rocks Greywacke Old Red Sandstone Carboniferous or Mountain Limestone Coal-Measures

Fig 2

COAST SECTION FROM BROAD HAVEN TO MILL HAVEN, St BRIDES BAY PEMBI

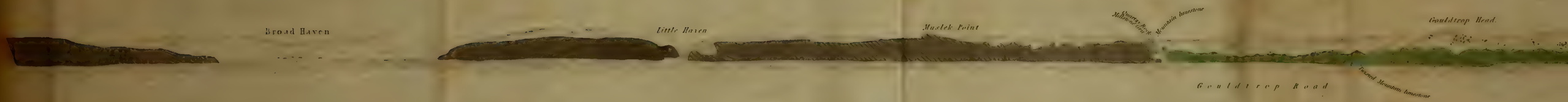


Fig 4.

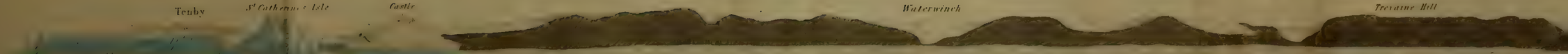
ELIDUG STACK.

Fig 3.

WEST ANGLE.

Fig 6.

COAST SECTION FROM TENBY TO SANDERSFOOT.



asures

DRYSON HAVEN.

Large Blocks of Trap over this Country

Trap blocks on this shore

Fig 2.

BROAD HAVEN TO MILL HAVEN, St BRIDES BAY PEMBROKESHIRE.

Fig 5.

COAST SECTION NEAR STACKPOLE QUAY.

Fig 6.

AST SECTION FROM TENBY TO SANDERSFOOT.

T.Bradley Sculp

Fig 1

Order of the Strata in the vicinity of Lyme Regis Dorset

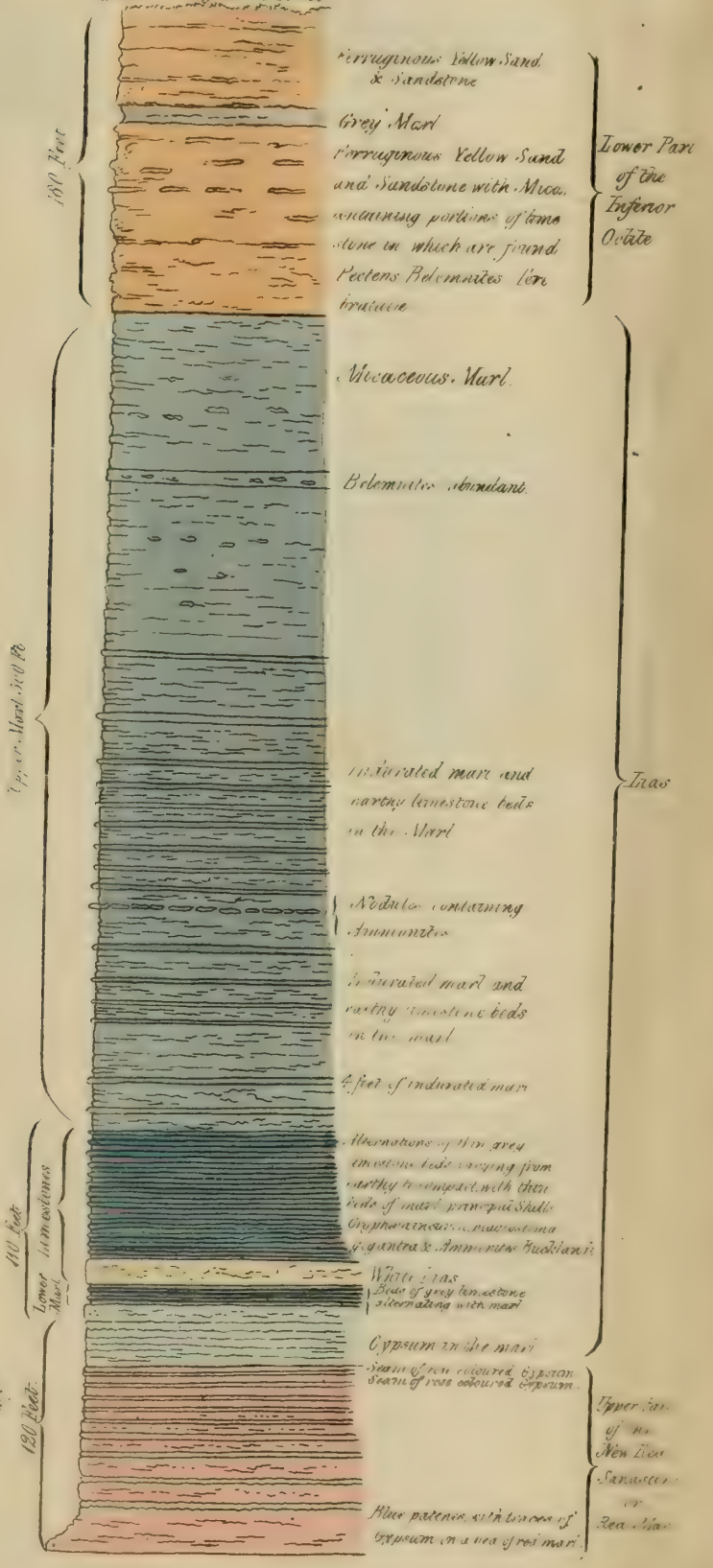


Fig 2

Fault at the Bottom of Pinhay Cliff

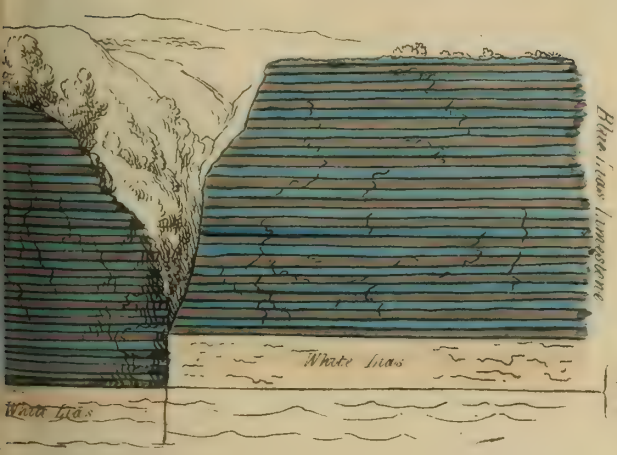
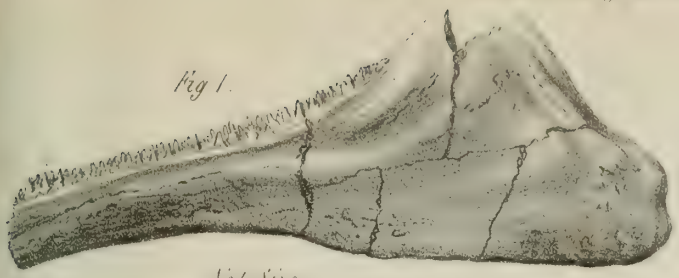


Fig 1.



Nat Size

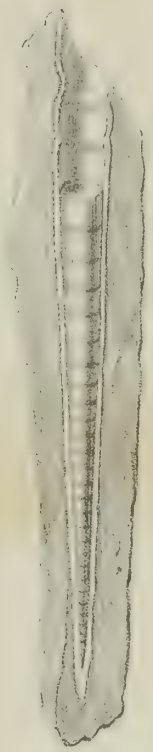
Fig 2

Nat Size

Fig 3

Nat Size

Fig 4

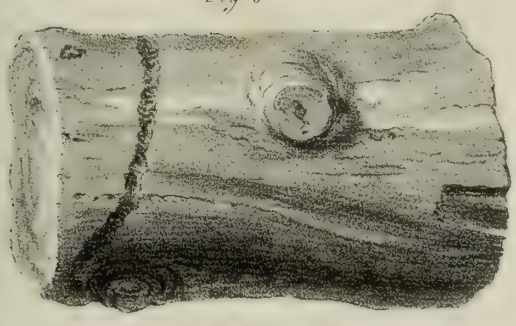


Nat Size.

Fig 5

Nat Size.

Fig 6



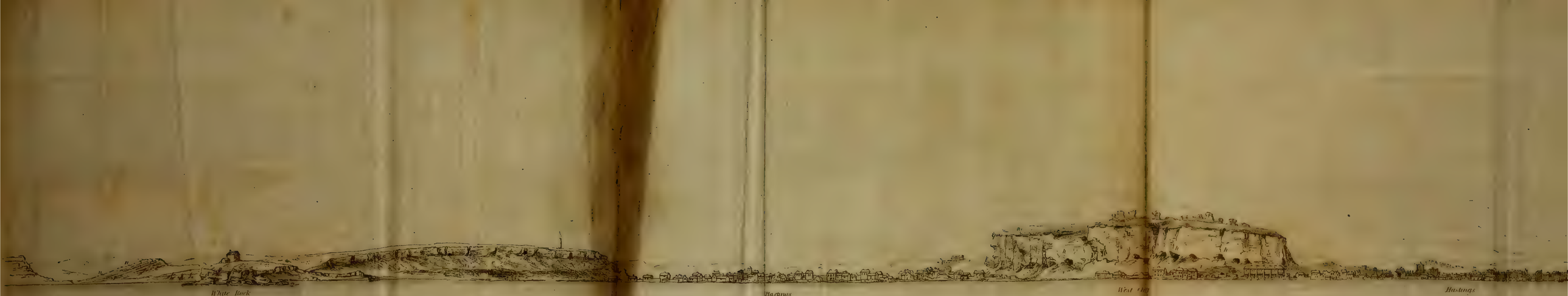
One half of the Natural Size

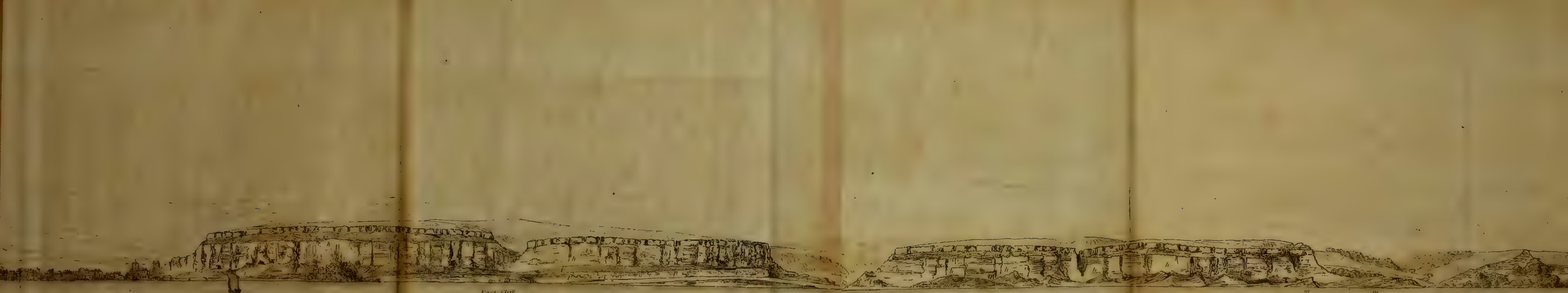
Fig 7

Nat Size

G Scharf lithog

FOSSILS OF THE LIAS NEAR LYME REGIS.


White Rock
Hastings
Hastings



ELEVATION OF THE CLIFFS TOWARDS THE SEA AT HASTINGS IN SUSSEX, FROM WHITE ROCK ON THE WEST TO CLIFF END ON THE EAST

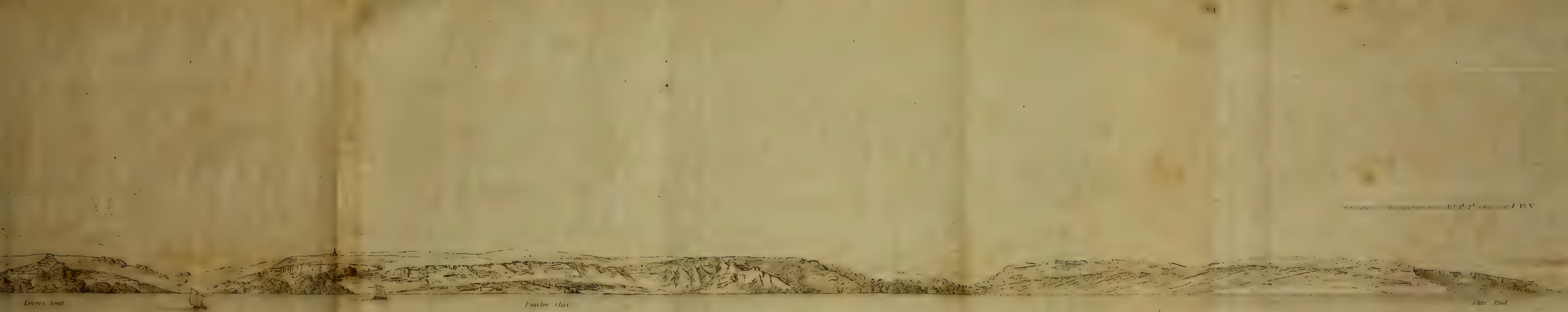

Lovers Seat
Faulee Clift
Clift End

Fig 1

Fig 2

Fig 3

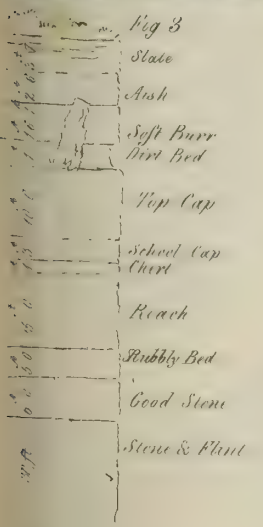


Fig 4.

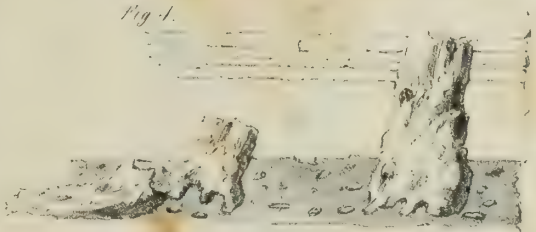


Fig 5

Fig 6

Fig 7

Fig 9.

Fig 10

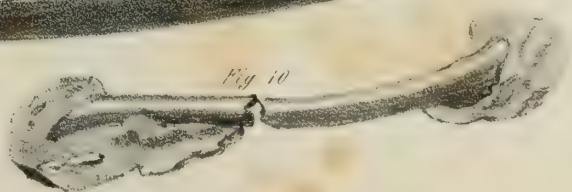
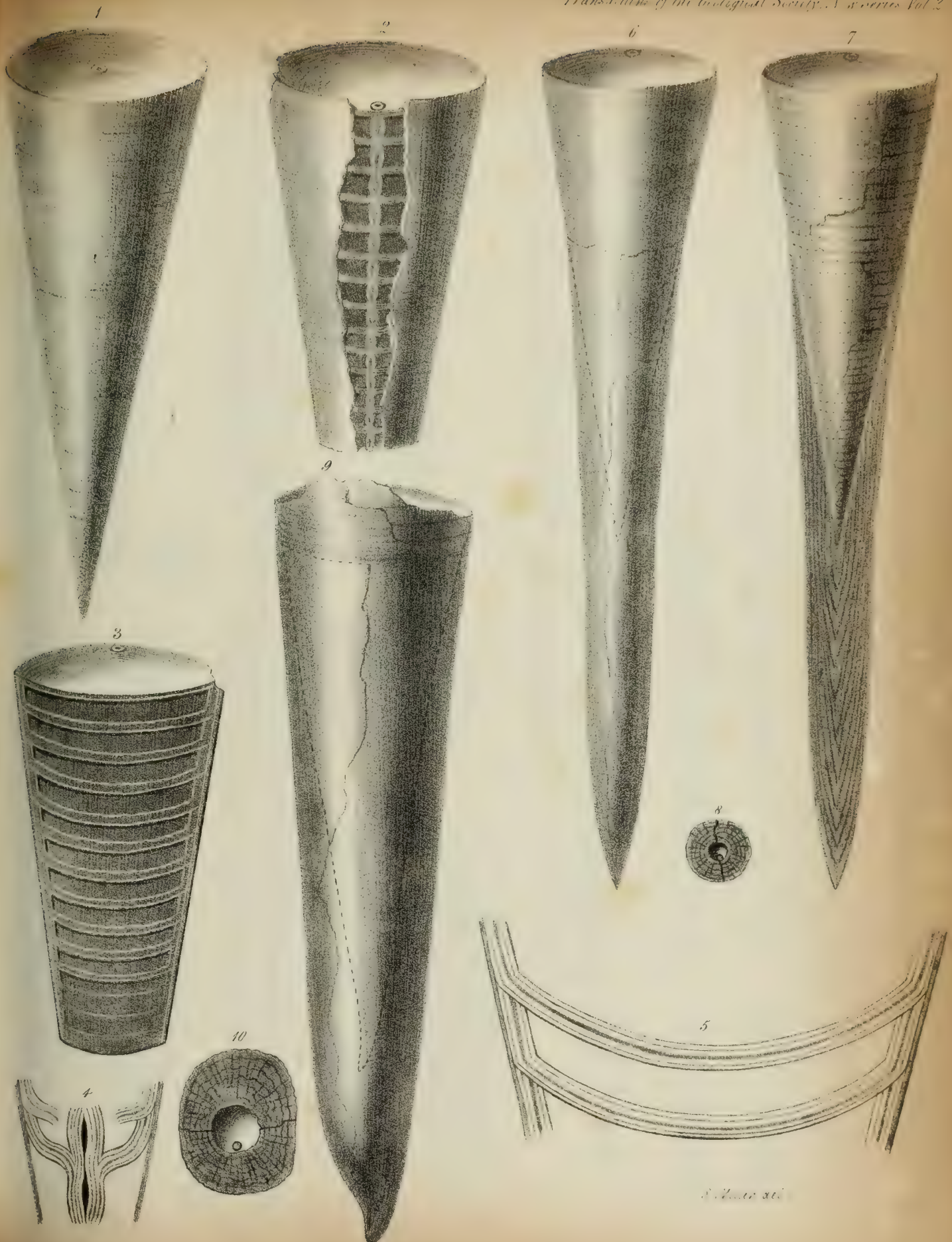


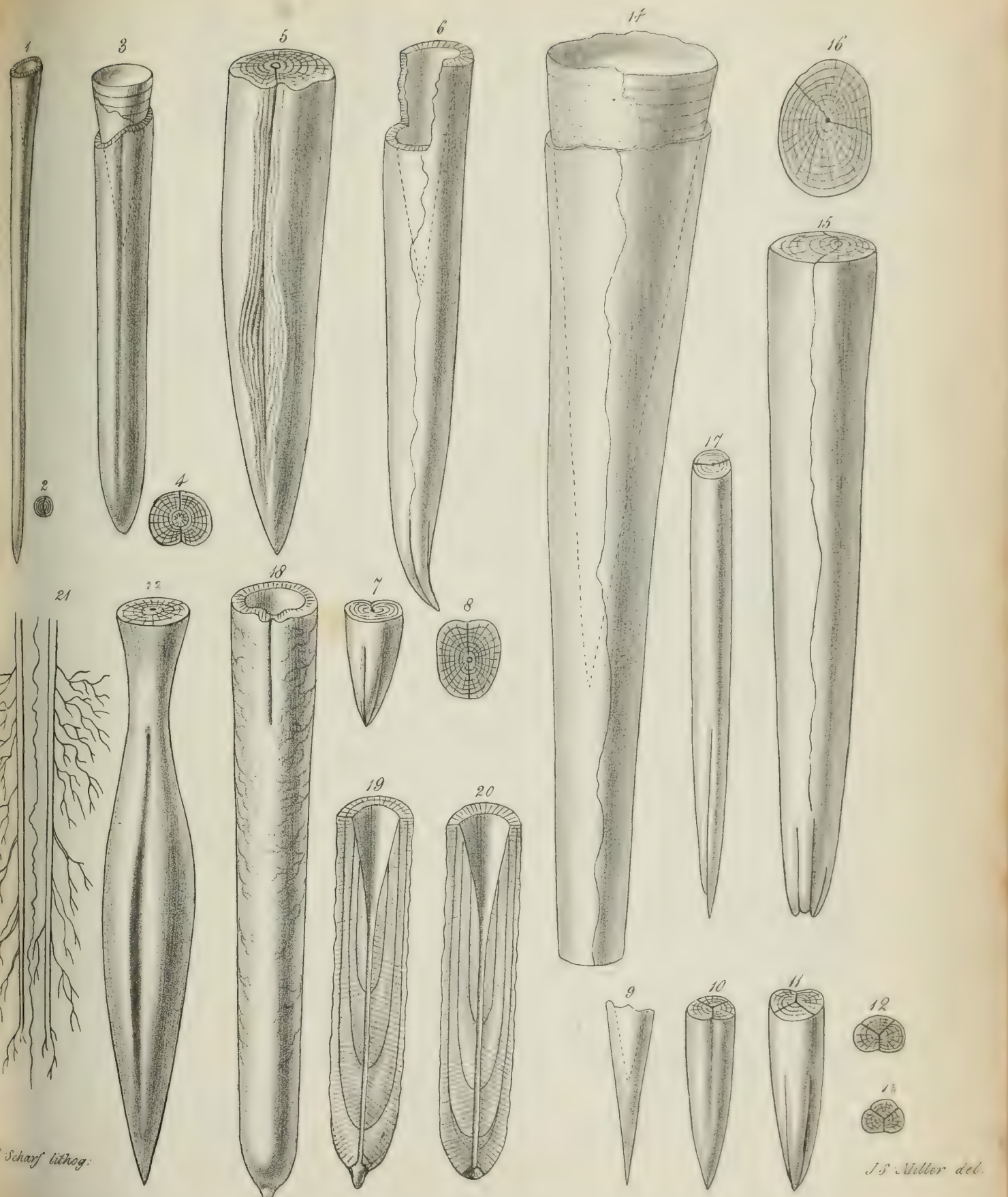
Fig 11

Drawn by T. Webster

I of PURBECK & PORTLAND



BELEMNITES.


1
3
5
6
17
16
15
2
4
17
21
22
18
7
8
19
20
9
10
11
12
13
Scharf lithog:
J S Miller del.

BELEMNITES.

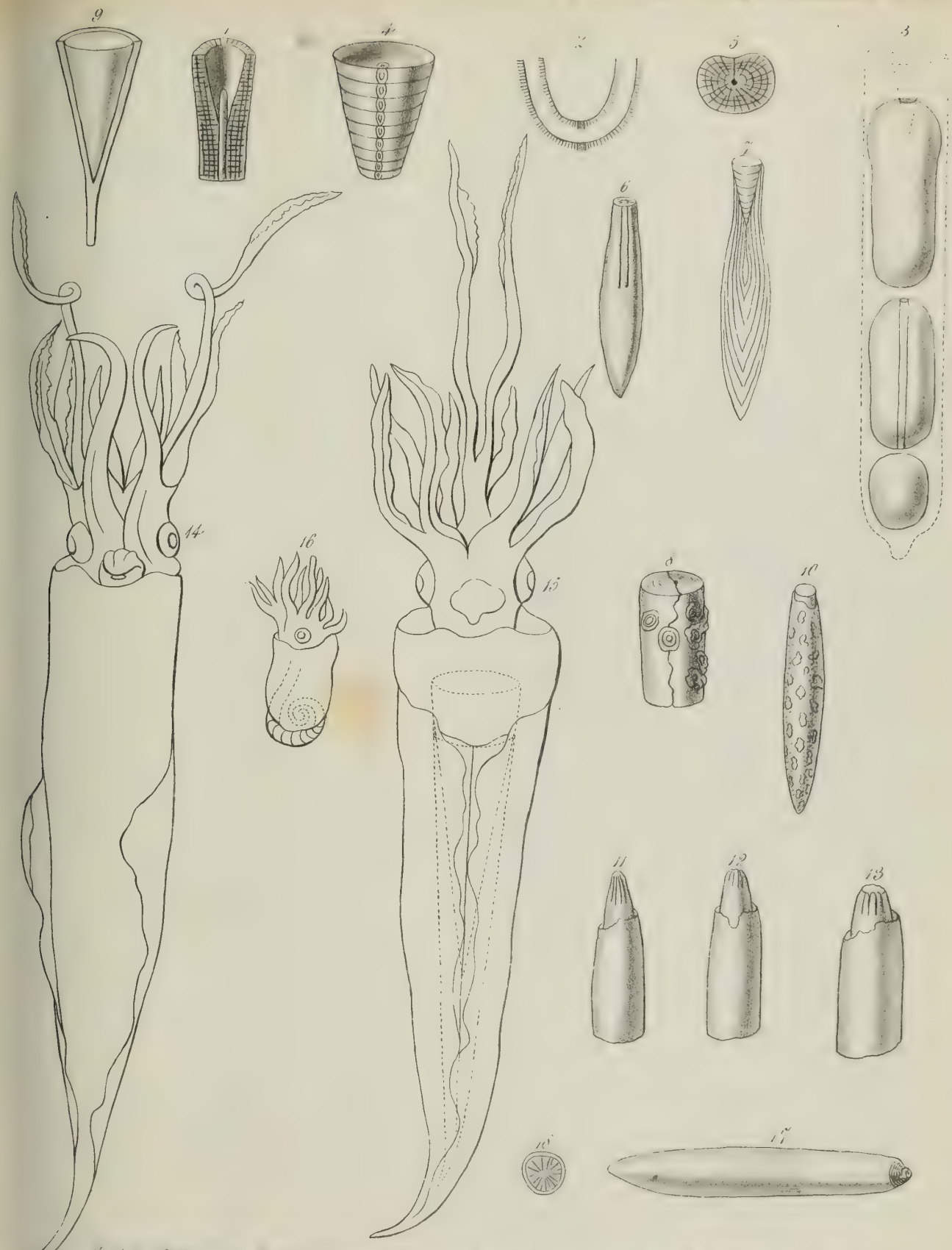


Fig 1 to 13 Belemnites Fig 14 — 15 Sepia Loligo with the supposed [illegible] of the Belemnite [illegible] the living Animal. Fig 16 Spirula fragilis. Fig 17 — 18 Actinocamax

G. Scharf lithog.

BELEMNITES &c.

J. S. Miller del.

SECTION OF PART OF FORFARSHIRE FROM N. TO S. THROUGH BAKIE LOCH.

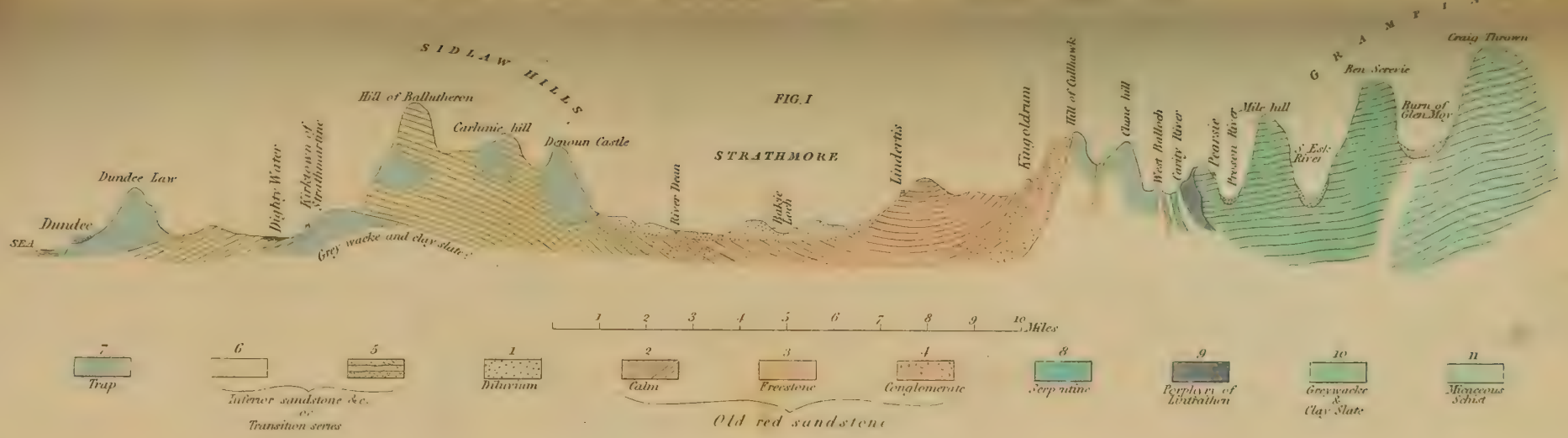
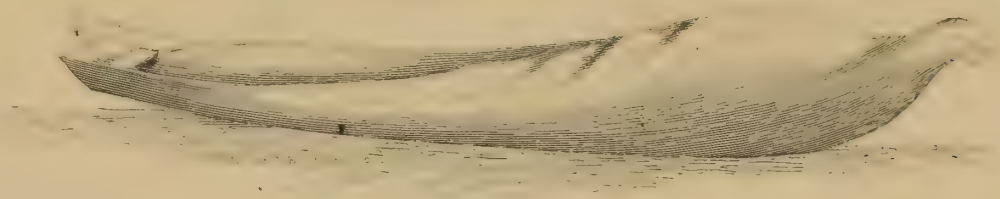


FIG. II



CANOE FOUND IN THE PEAT OF THE LOCH OF KINNORDY

SUPPOSED SECTION OF THE MARL DEPOSITS IN THE BAKIE LOCH

PART OF FORFARSHIRE,

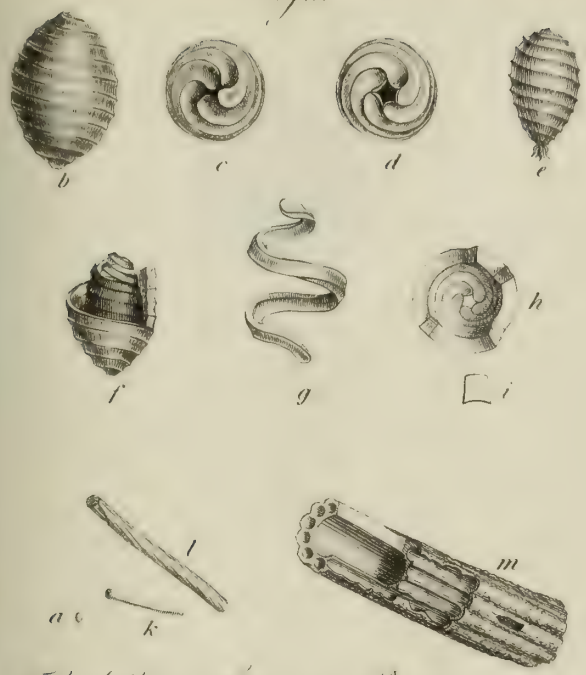
in which the principal deposits of *SHELL MARL are situated.*

1. Shell Marl
2. Old Red Sandstone
3. Inferior Sandstone, Shale &c.
4. Trap { Greenstone / Porphyry
5. Dike of Serpentine
6. Greywacke & Clay Slate
7. Micaceous Shist

Line of Section Fig. I. Plate X.

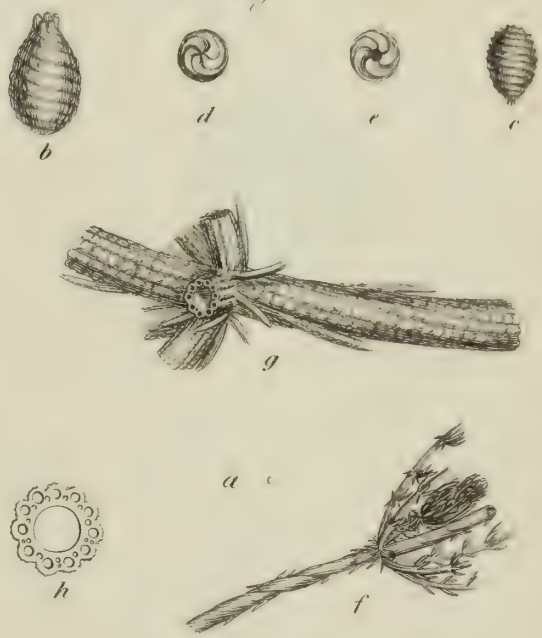
Furlongs 8 4 0 Scale of Miles 1 2 3 4

Fig. 1.



Fossil Chara from the Rock-marl.

Fig. 2.

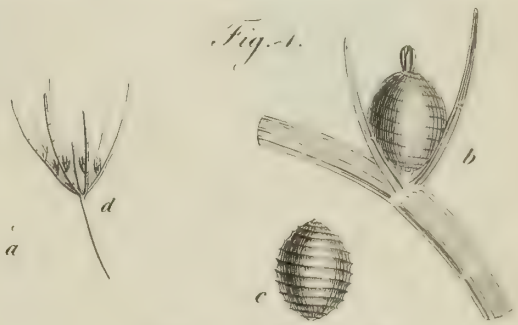


Chara hispida.

Fig. 3.

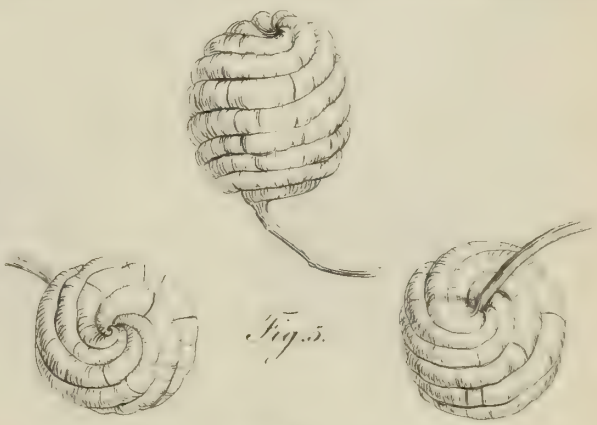
Chara vulgaris.

Fig. 4.



Chara flexilis?

Fig. 5.

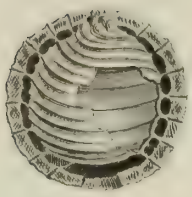


Helicteras.

J.D.C. Sowerby del.t et sculp.t

Chara &c. from the Marl Lakes of Forfarshire.

2

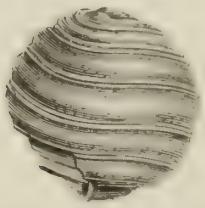


b

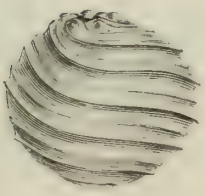
c

a

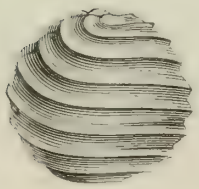
1



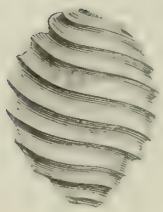
3



4

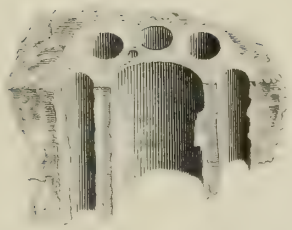


5



Chara Medicaginula.

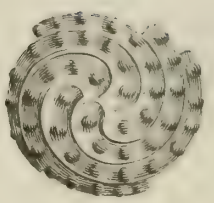
6



Stem of C. Medicaginula.

7

8



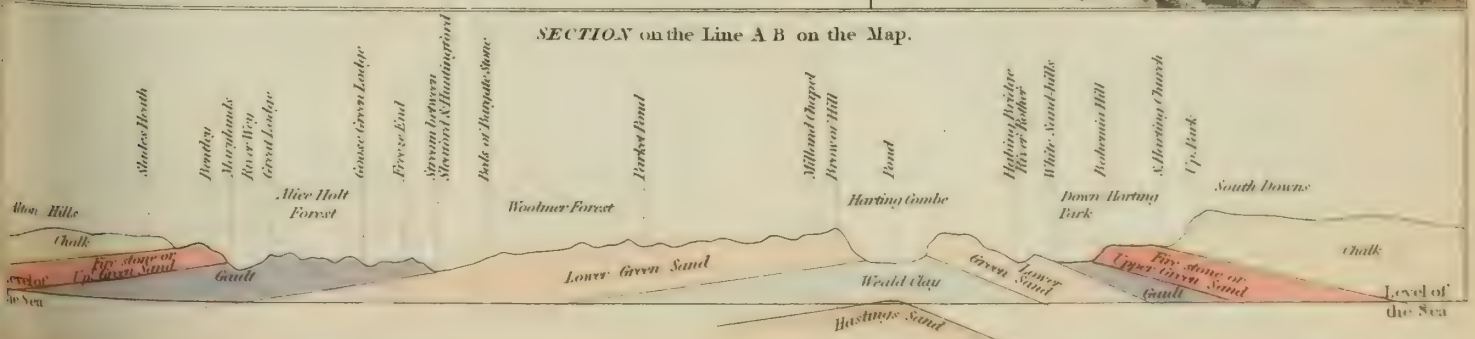
Chara tuberculata.

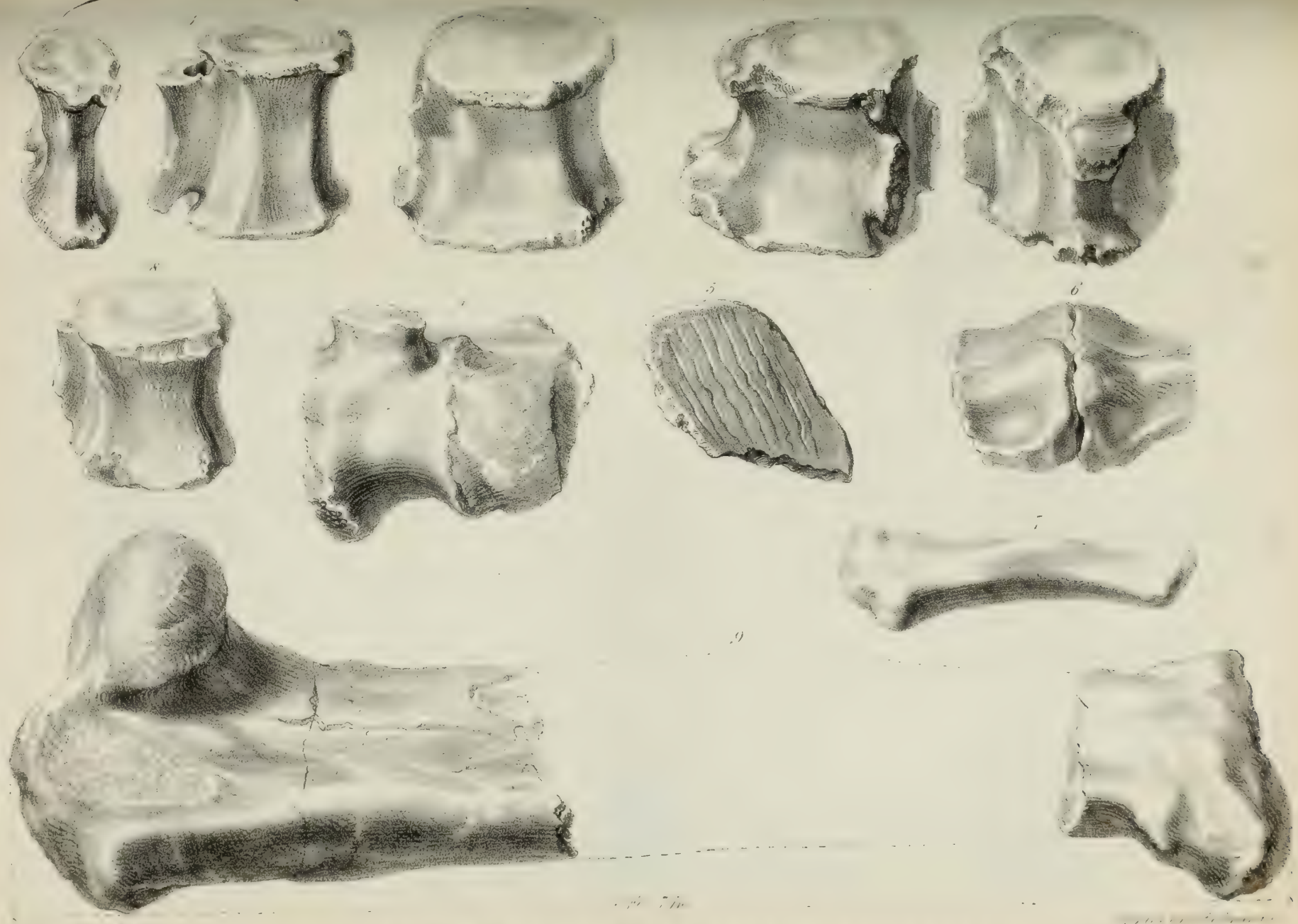
J. C. Sowerby del. et sculp.

Gyrogonites.

Geological Map of a District of the WEST OF SUSSEX and of PARTS OF SURREY & HANTS.

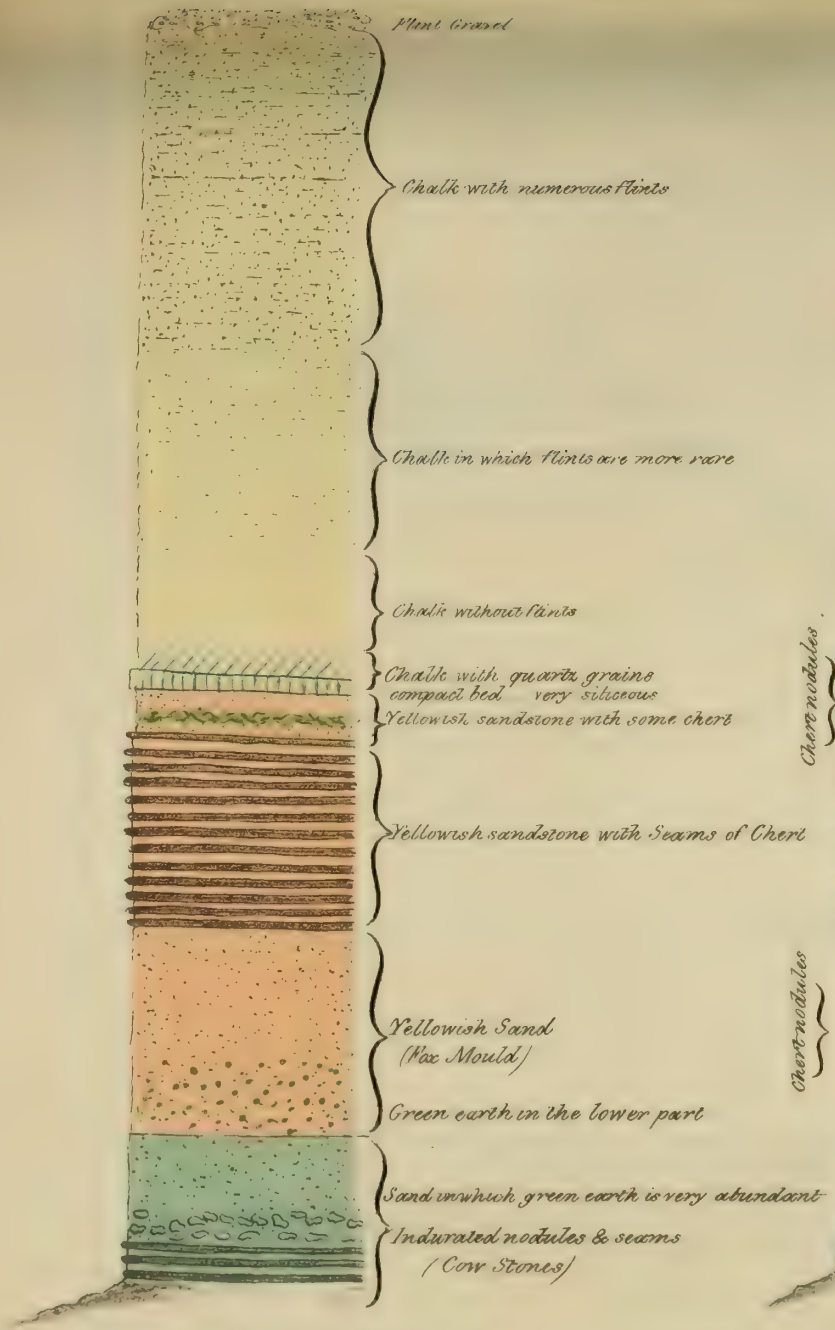
SECTION on the Line A B on the Map.



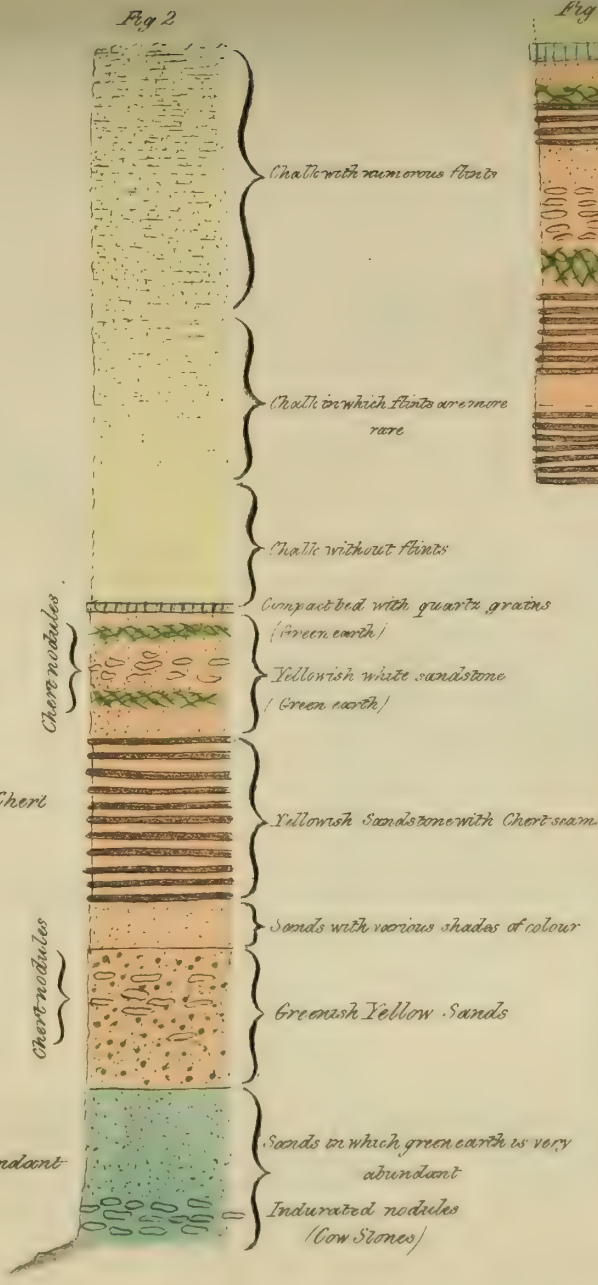


[illegible] BONES FOUND [illegible]

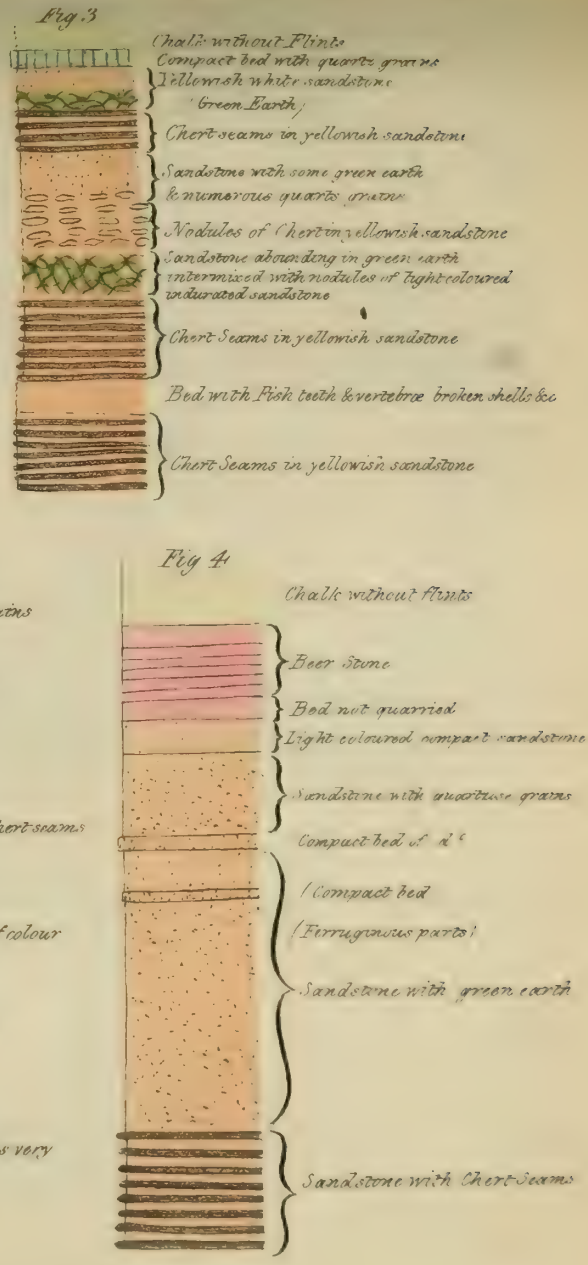
No. 1. 2. 3. 4. 5. 6 & 7 found N. of Loxwood No. 8 & 9 at Headfoldwood Common The Vertebræ and Number 7 are drawn half the natural Size.



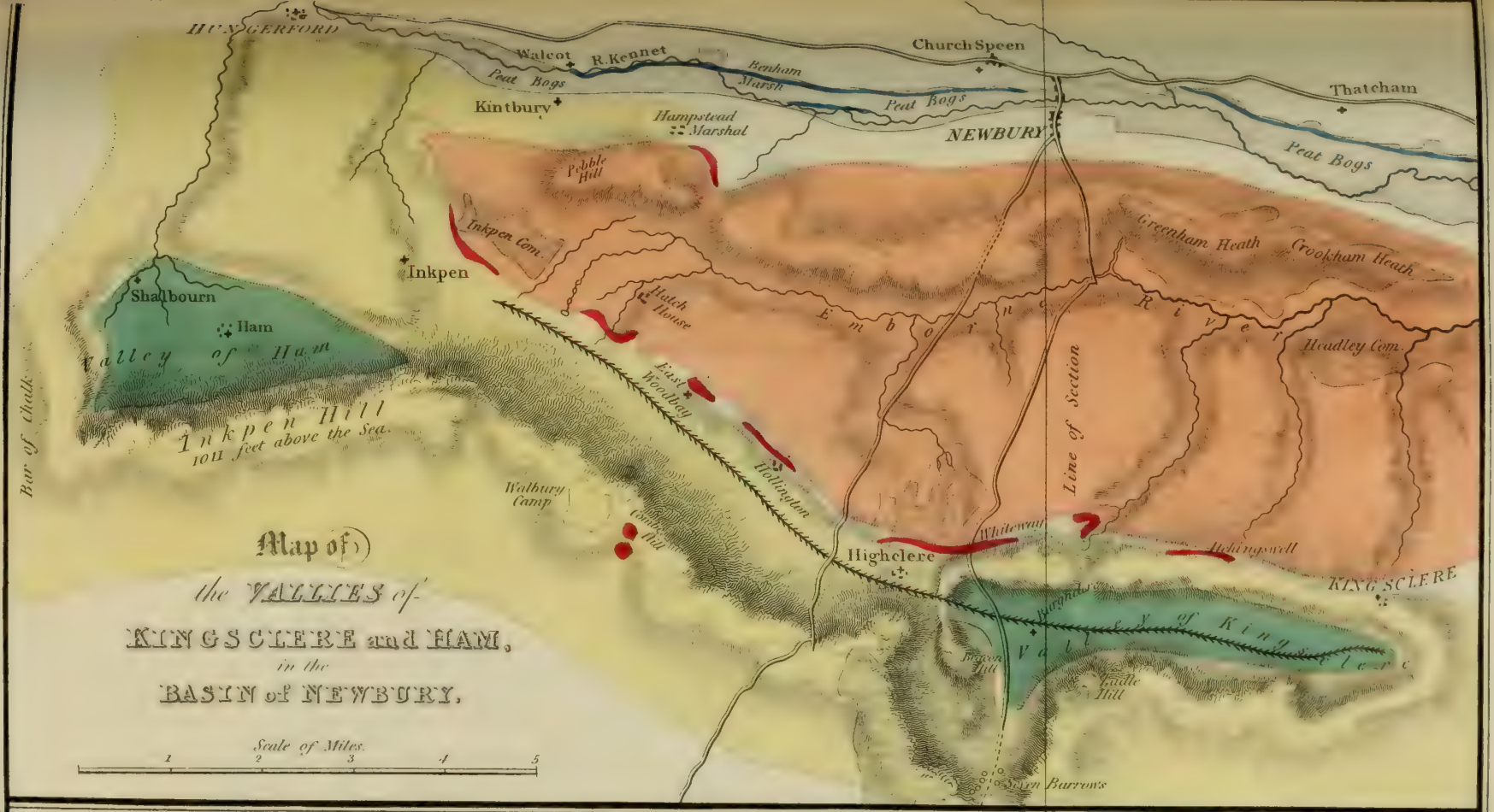
Section of the Chalk & Sands beneath it
near Lyme Regis Dorset



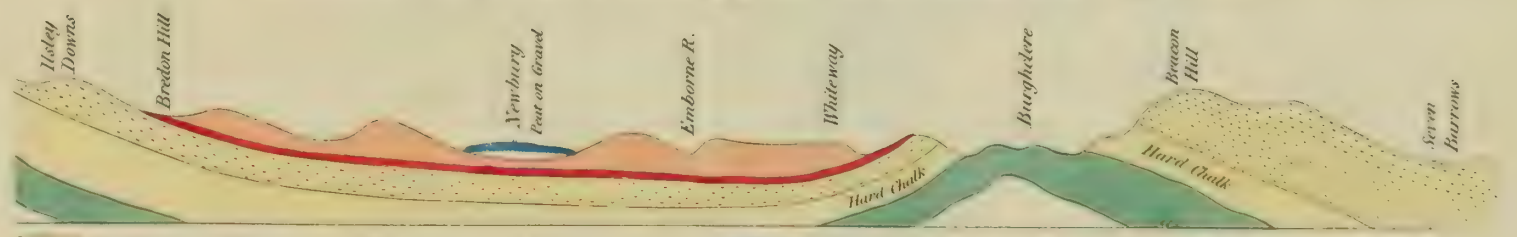
Section of the Chalk & Sands beneath it
at White Cliff Beer Devon



Position of the Beer Stone
Beer Devon



Section across the Vale of Newbury from Seven Barrows to the Ilsley Downs.



Chalk, the upper Beds containing Flints, as expressed by the dotted lines.

Fire Stone or upper Green Sand containing Beds of Chert.

Anticlinal line marking the opposite Dip of the Chalk on each side of it.

Shell marl and Calcareous Tufa.

Sand, Gravel, Loam, and Clay, of the Plastic Clay formation.

Red and White Beds of Plastic Clay, used for Brick and Tiles.

W. Bradland, Sc.

GEOLOGICAL MAP
of part of
JAMAICA.

St Anns Bay
Don Christophers Cove
Mammee Bay
Roaring R.
Ocho Rios Bay
White River Bay
Ora Cabessa Bay
Fort Littleton
Galina Point
Fort Haldane
Port Maria
Pagee Point
Green Cove
Forsters Cove
Blowing Point
Don Christophers Point
Agua-alta
Amoretto Bay
Fort Brunswick
Free Point
Dry River
Big Tree River
Little Spanish River
Palmetto Point
White River
Buff Bay
Great Spanish River
Orange Bay
Savanna Point
Bowart Island
Sweet River
Dennis River
Welsh Woman's Point
Whydah Bay
Rio Grande
Pompeys Bluff
Ship Island
Wag Wee Gully
Navy Island
Fort George
Fort Antonio
Folly Point
Woods Island
Turtle Crawle
Gold Harbour
Folly Bay
Pellew Island
Salt Creek Bay
Fairy Hill Bay
Lynches Bay
N.E. Point
Priestmans River
Long Bay
Mulatto River
Christmas Island
White River
Manchineel Harbour
Innes Bay
Hectors River
Plantain Garden R.
Harbour
E. End or Morant Point.
Rocky Point Bay
Port Morant
Fishermans Bay
Swimmers Bay
Morant Bay
Bedwedere Point
White Horses
Yallahs Point
The Salt Ponds
Yallahs Bay
Yallahs River
Yallahs Mountain
Cow Bay
Hope River
Bull Bay
Cane River
Kingston Harbour
Port Royal
S.E. Key
Long Key
South Key
Kingston
Greenwich
Rio Cobre
Spanish Town
Port Henderson
Old Harbour
Gallion R.
Old Harbour
C.t Goal
Red Hills
Wreck Bay
Wreck Reef
Salt River B.
Pedro B.
Pigeon I.
Man of War Keys
Pelican Keys
Bare Bush Key
Half Moon Keys
Portland Key
Portland Point
Jacksons Bay
Rocky Point
Carlisle Bay
Rio Minho
Portland Ridge
Alligator Pond Keys
Alligator Pond R.
Alligator Pond Bay
Calabash Bay
Gurkells Point
Swift River
Warm Salt Spring
Mazcary Bay
The Bath
Gibraltar Pt.
Guanaboa Bay
Guiquar Bay
Manchester
Mountains
Montpelier
Don Christophers Cove
Cave River
Cave
Luidas Vale
Charlton
St John's Mountains
Scots Hall Town
Rose Hall Town
Charles Town
Moore Town
Content
Kingston
Port Royal
St Andrew.
St Thomas in the East.
St George.
St David.
Portland.
St Catherine.
St Dorothy.
St John.
Vere.
St Thomas in the Vale.
Clarendon.
St Mary.
St Ann.
Manchester.

Names of the Parishes in the County of Surrey.

1. Kingston.
2. Port Royal.
3. St Andrew.
4. St Thomas in the East.
5. St George.
6. St David.
7. Portland.

Names of the Parishes in the County of Middlesex.

8. St Catherine.
9. St Dorothy.
10. St John.
15. Vere.
11. St Thomas in the Vale.
12. Clarendon.
13. St Mary.
14. St Ann.
16. Manchester.

British Statute Miles
1 2 3 4 5 10 15 20 25 30

a. Submedial, or Transition Rocks.
b. Trap Rocks, associated with the above.
c. Red Sandstone & Conglomerate.
d. Coal Measures.
e. Porphyritic Conglomerate & Trap Rocks.
f. White Limestone Formation.
g. Extinct Volcano.
h. Diluvium and Alluvium.
i. Coral Islands.

Fig 1.

St George's Gap

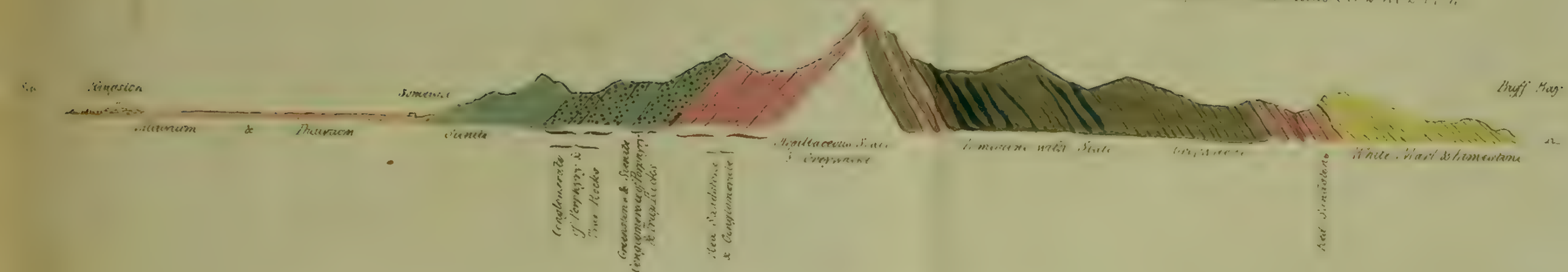


Fig 2

Section from the Sea near Kingston to Forster's Cove St Mary's

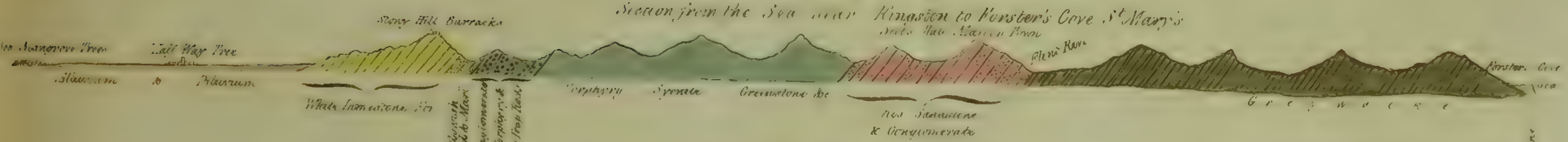


Fig 3

Section from Old Harbour to Luidas Vale

St Johns Mountains

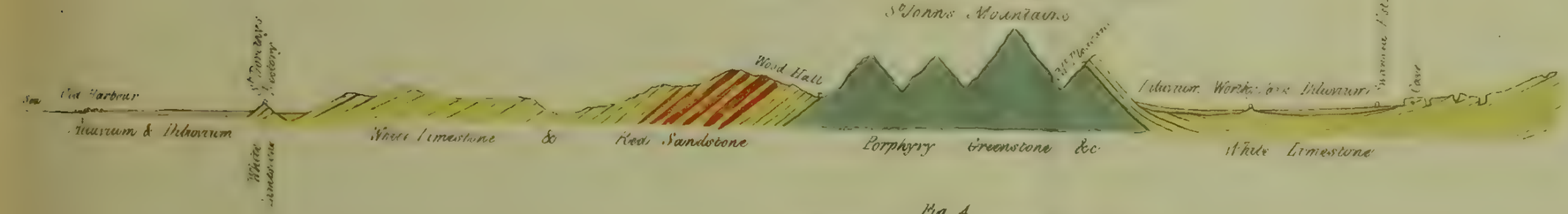
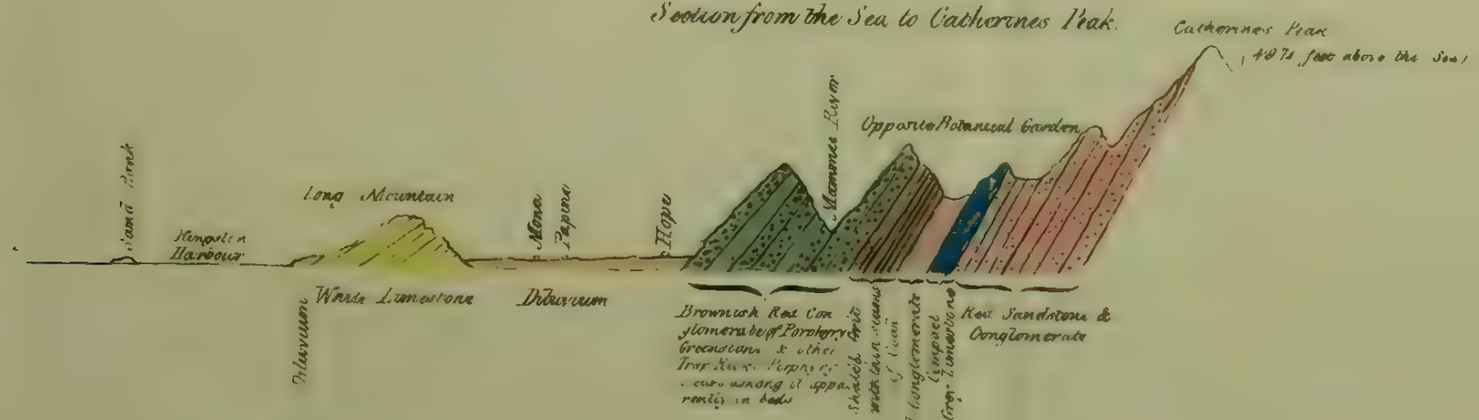


Fig 4

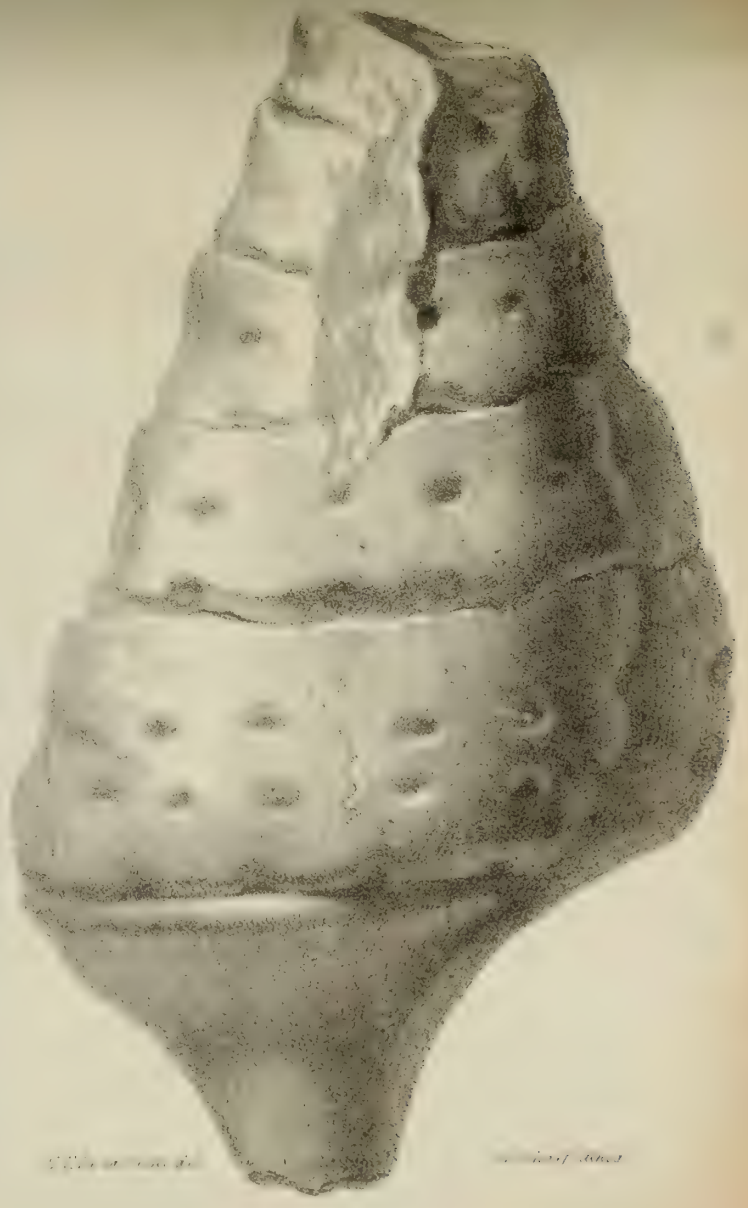
Section from the Sea to Catherines Peak.



H T De la Beche del

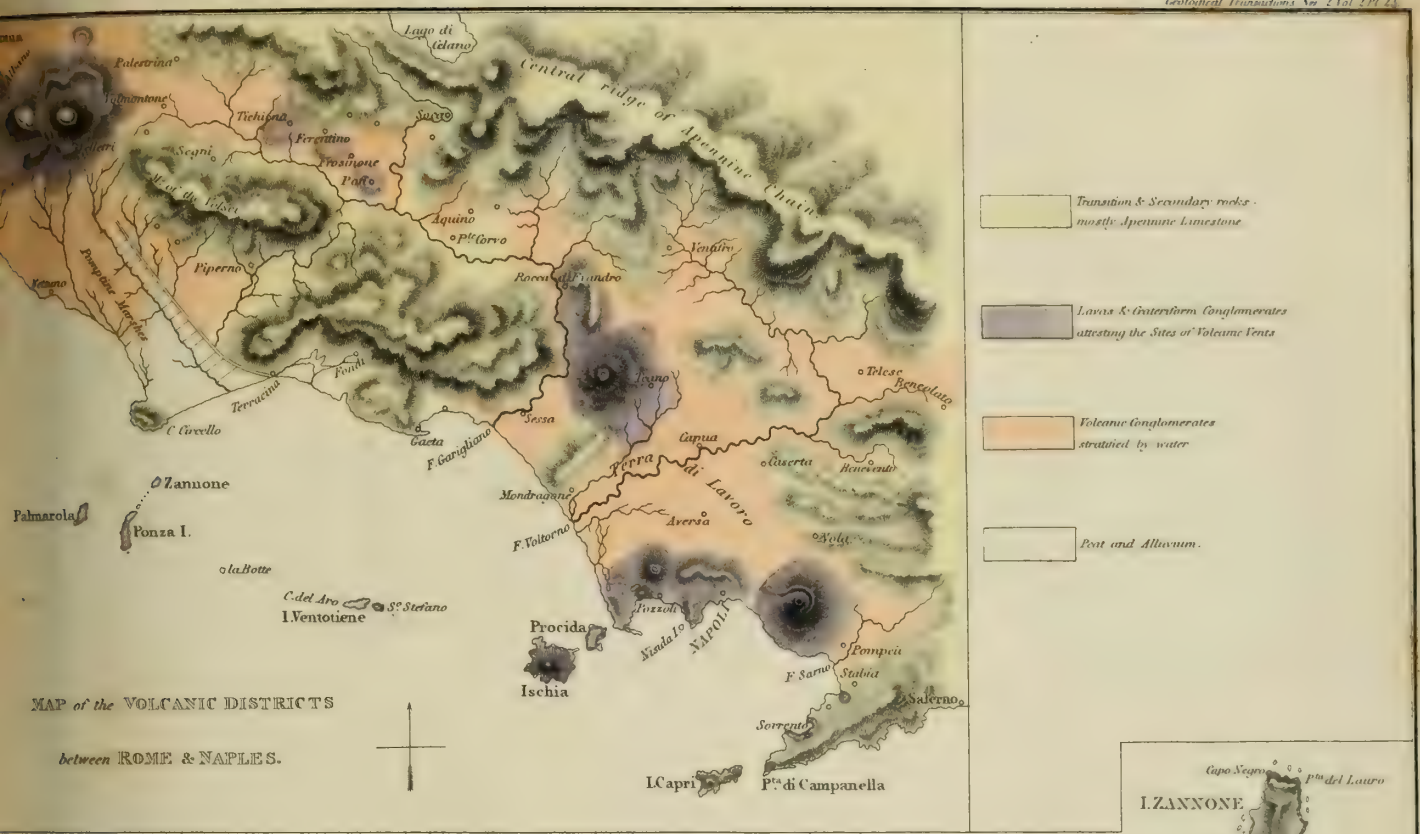
Printed by C Hullmandel

Natural Bridge near Mount Olive St. Thomas in the Vale

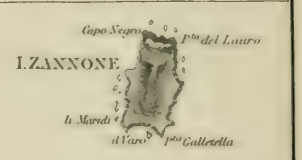


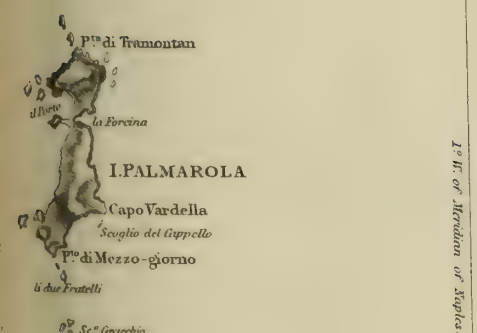
Nat. Size.

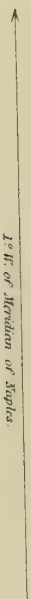
PANORAMIC VIEW FROM STRAWBERRY HILL, ONE OF THE ST. ANDREW'S MOUNTAINS, JAMAICA.

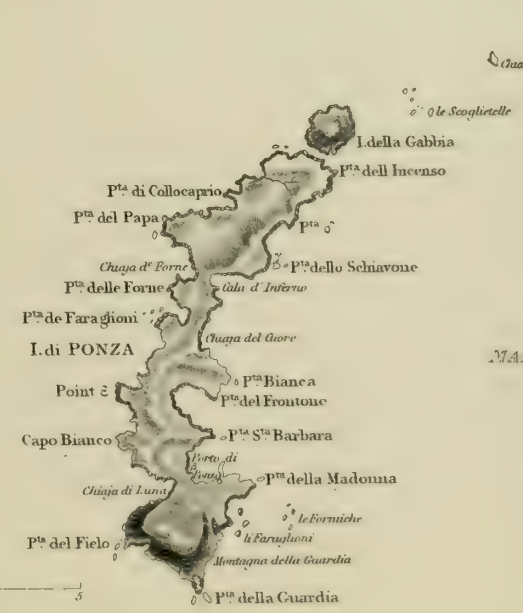


MAP of the VOLCANIC DISTRICTS between ROME & NAPLES.









MAP of the TRACHYTIC GROUP of the PONZA ISLES.

Scale of Five Geographical Miles.

1 2 3 4 5

Fig. 1.

View of the Island of Ponza from the East side, about 4 miles distance.

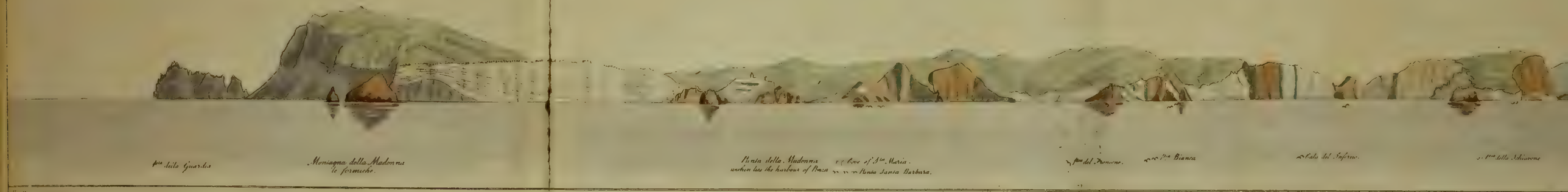
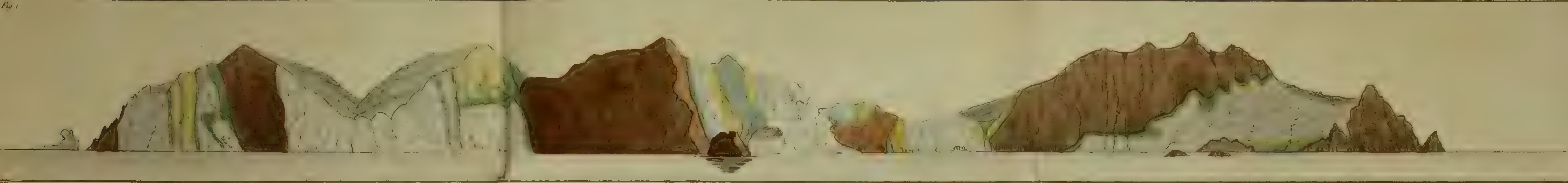


Fig. 2.

about 4 miles distance.
Pta Bianca.
Cala del Inferno.
Pta dello Schiavone
Pta 8 (Map)
Pta del Incenso.
Isle of la Gabbia
Mte Circello
Line of insular rocks connecting la Gabbia with Zannone.
Island of Zannone
Range of Apennines in the distance
Mons.a della Guardia
Punta del Fielo
Trachytic Conglomerate (Tufa)
Vegetation.
Fig. 3
Capo Bianca.
Pta del Fielo South side.
Stratified Tufa
Montagna della Guardia from the South.
Strata of Red Tufa.
Pta della Guardia.
Chiaja di Luna Isle of Ponza.
Fig 4
Rock of contorted & Globiform Pitchstone.

Eastern side of Ponza continued

Fig. 1



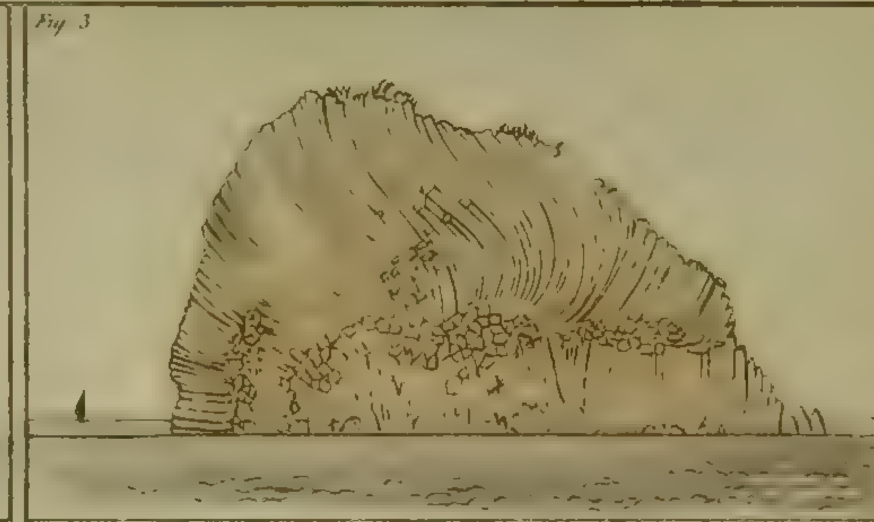
Pta ... Side — Mons.a del Cuore — Scoglio del Cuore — Cala del Inferno — Le Forne freshwater spring — Mons.a della Schiavone — Punta della Schiavone

Fig. 2

Eastern side of Ponza continued

Pta della Schiavone East side — Point 4 Map — Scoglio le Spaccasella — the same ... here passes ... Trachyte — Point 5 in Map

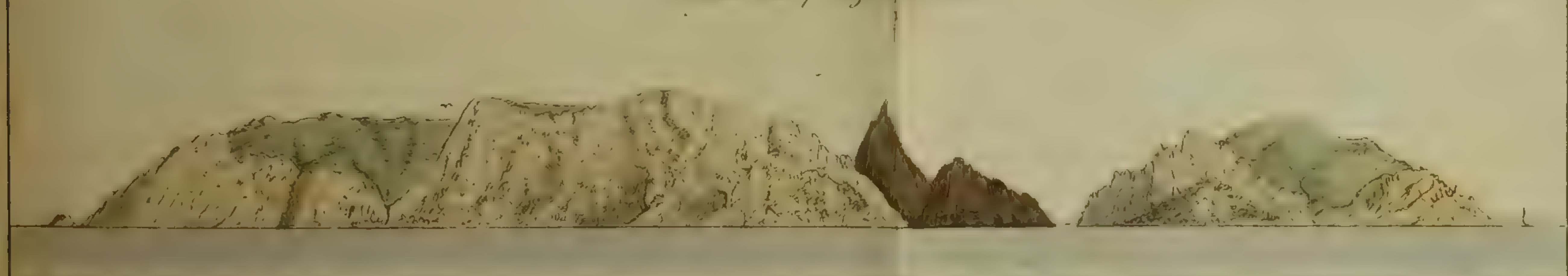
Fig. 3



Rock of Columnar Trachyte near the N.E. point of Palmarola

Fig. 4

Eastern side of Ponza continued



Point ... in Map — Extremely siliceous & cavernous Trachyte (Porphyre molaire) — Pta del Incenso — ... della Gabbia — Siliceous Trachyte

Fig. 5

Zannone seen from the South

Fig. 6

Siliceous Trachyte — Dolomite — Transition Limestone

Zannone seen from the East

Fig. 7

Ventotiene — Massive bed of compact gray stone surmounted by horizontal strata of loose Tufa — Apennines in the distance — Santo Stefano — Massive bed of gray stone supporting a few strata of Tufa

South east side of Ventotiene & S. Stefano

Fig 1

Fig. 2.

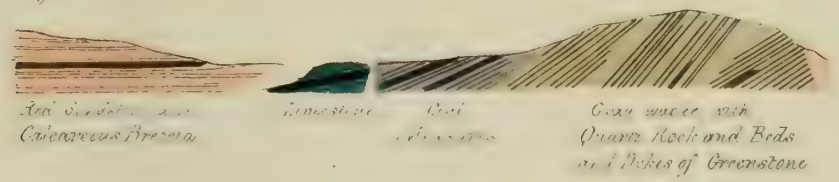
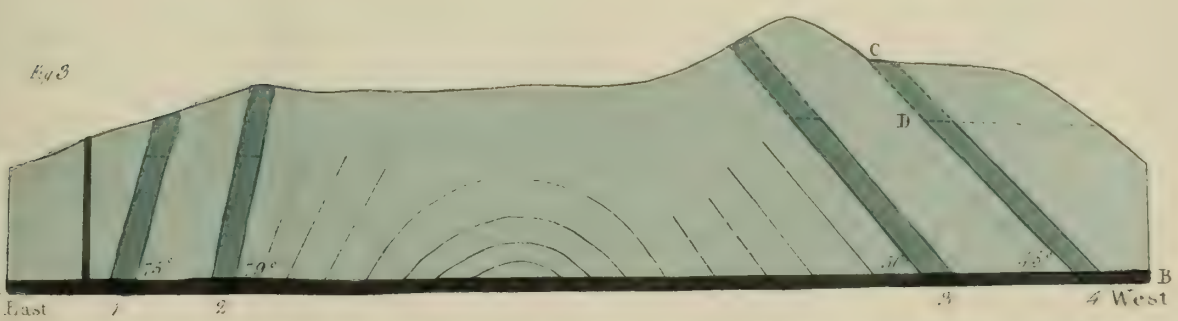


Fig 3



East & West Section of the W.R.E.N.S. N.E.S.T. near Dudley Scale 80 yards to an Inch. The lower Strata of Limestone, 2 3 are each 11 yards thick, the outer Strata (1 4) 8 yards. The Strata 2 3 4 meet at the southern end of the hill. The light coloured Strata are "Basin"

G. Scharf lithog.

Printed by C. Hullmandel

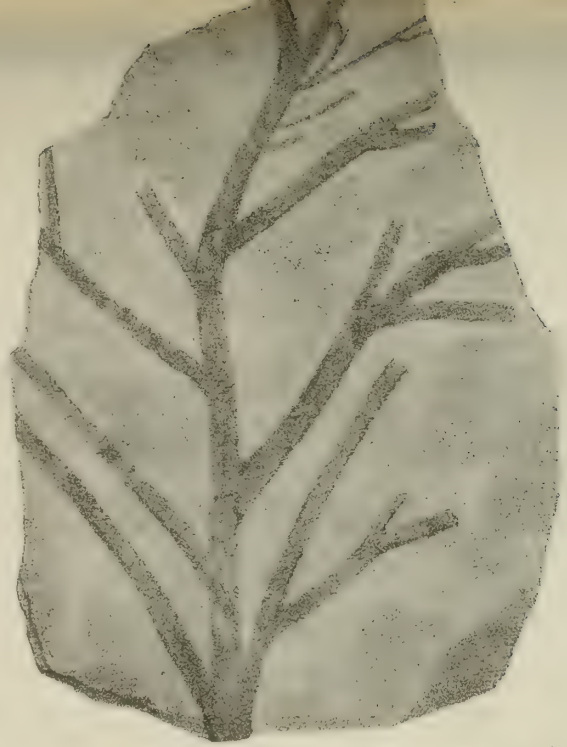


Fig 2

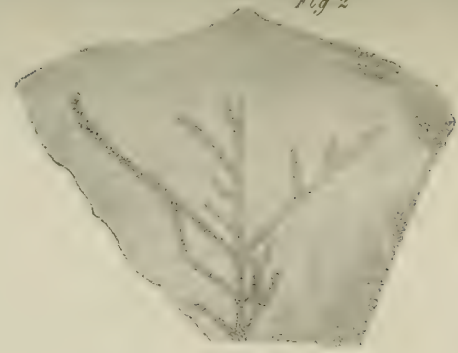


Fig 3.

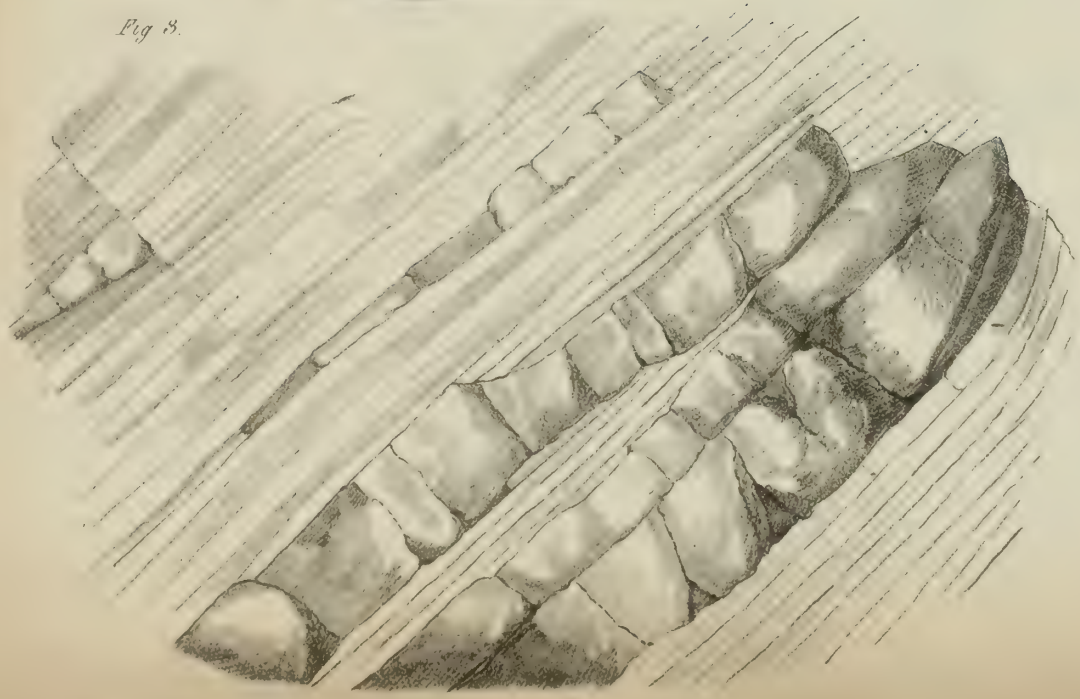
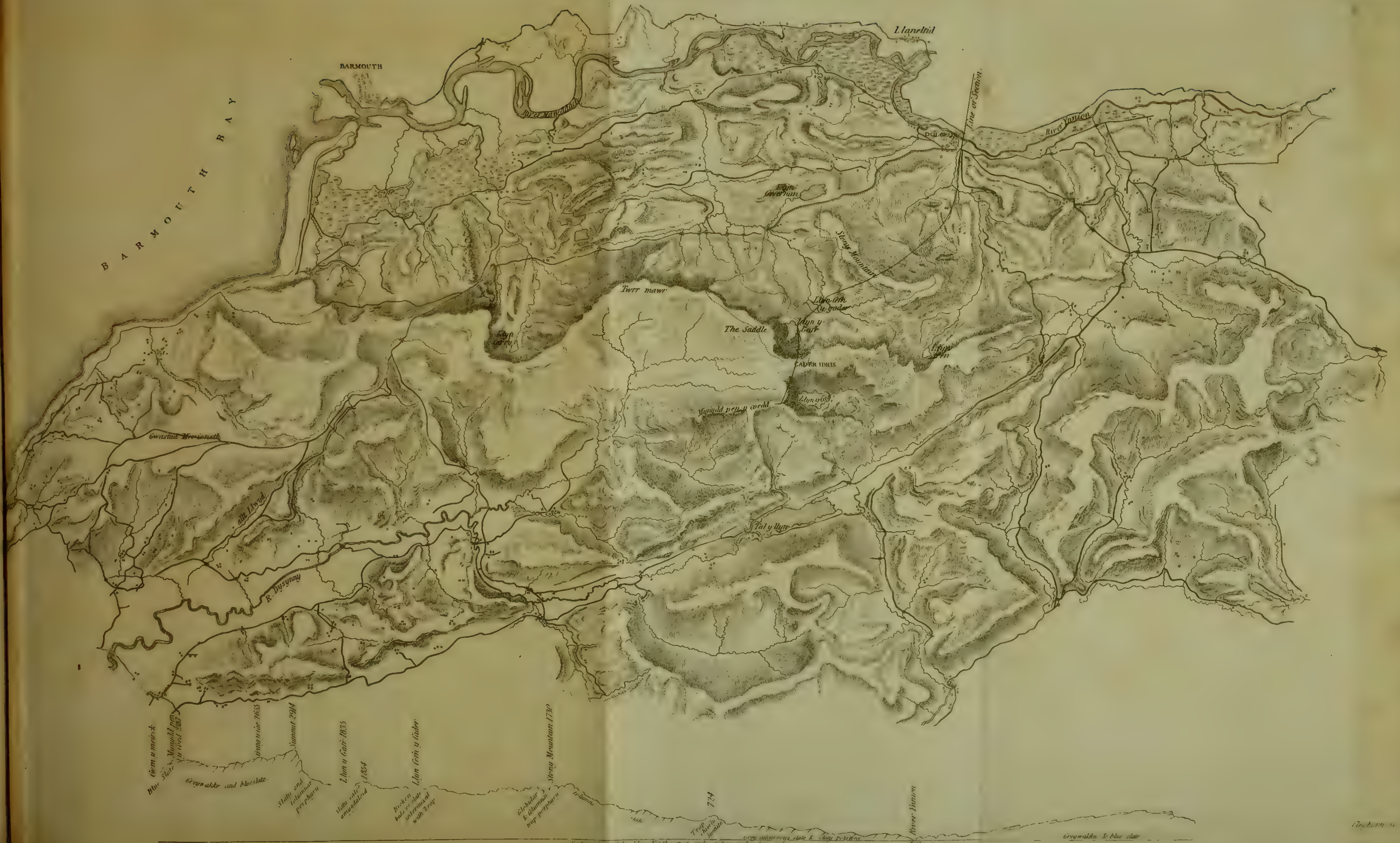


Fig 4.

G Scharf lithog

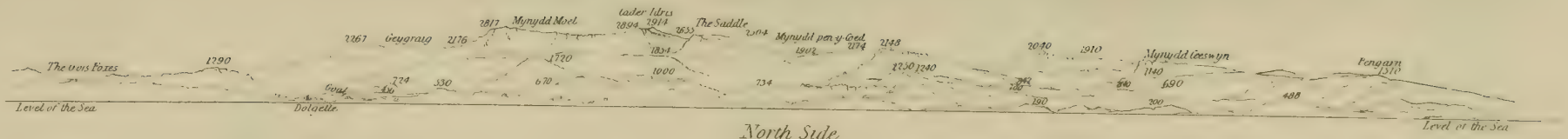
Printed by C. Hullmandel.

MAP OF CADER IDRIS.

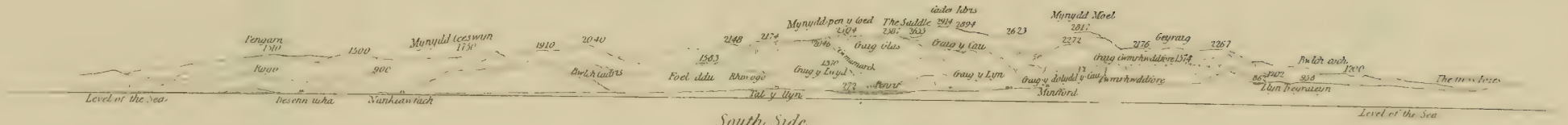


CADER IDRIS.

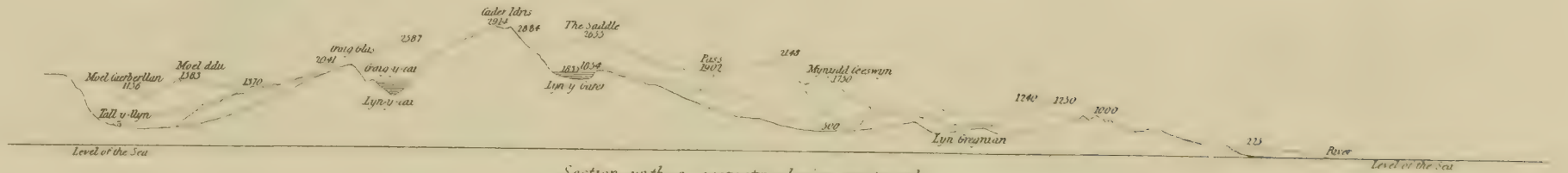
Geol Trans Ser 1 Vol 2 Pl XXIX



North Side.



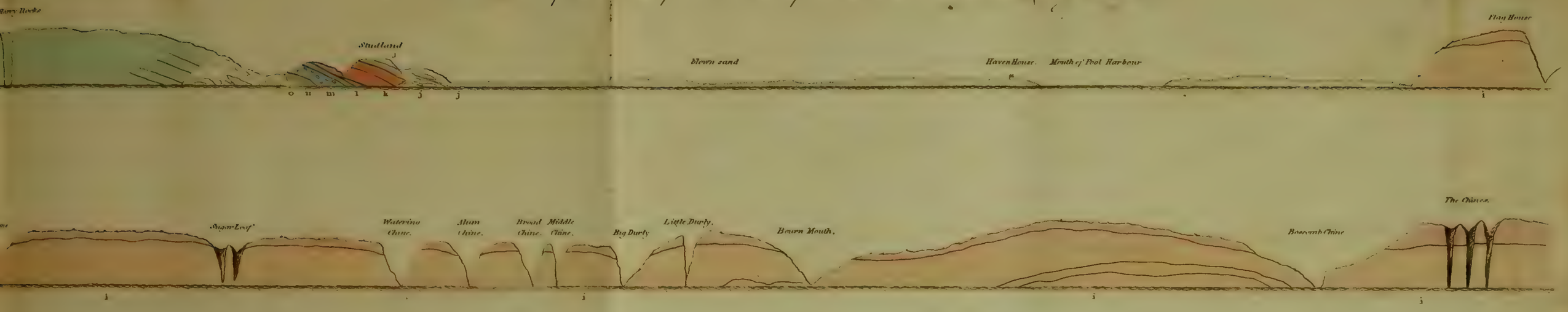
South Side.



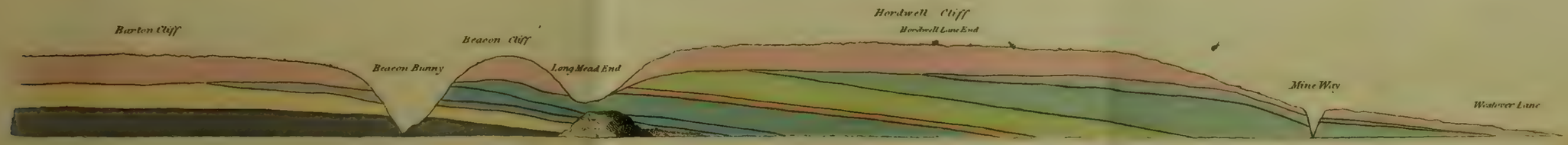
Section, with a geometrical view westward

Published by Longman

No. 1. SECTION of the Coast from Muddiford, Hants, to Studland Bay, Dorset.



No. 2. SECTION of the Lower Freshwater Strata in Hordwell, Beacon, and Barton Cliffs Hants.



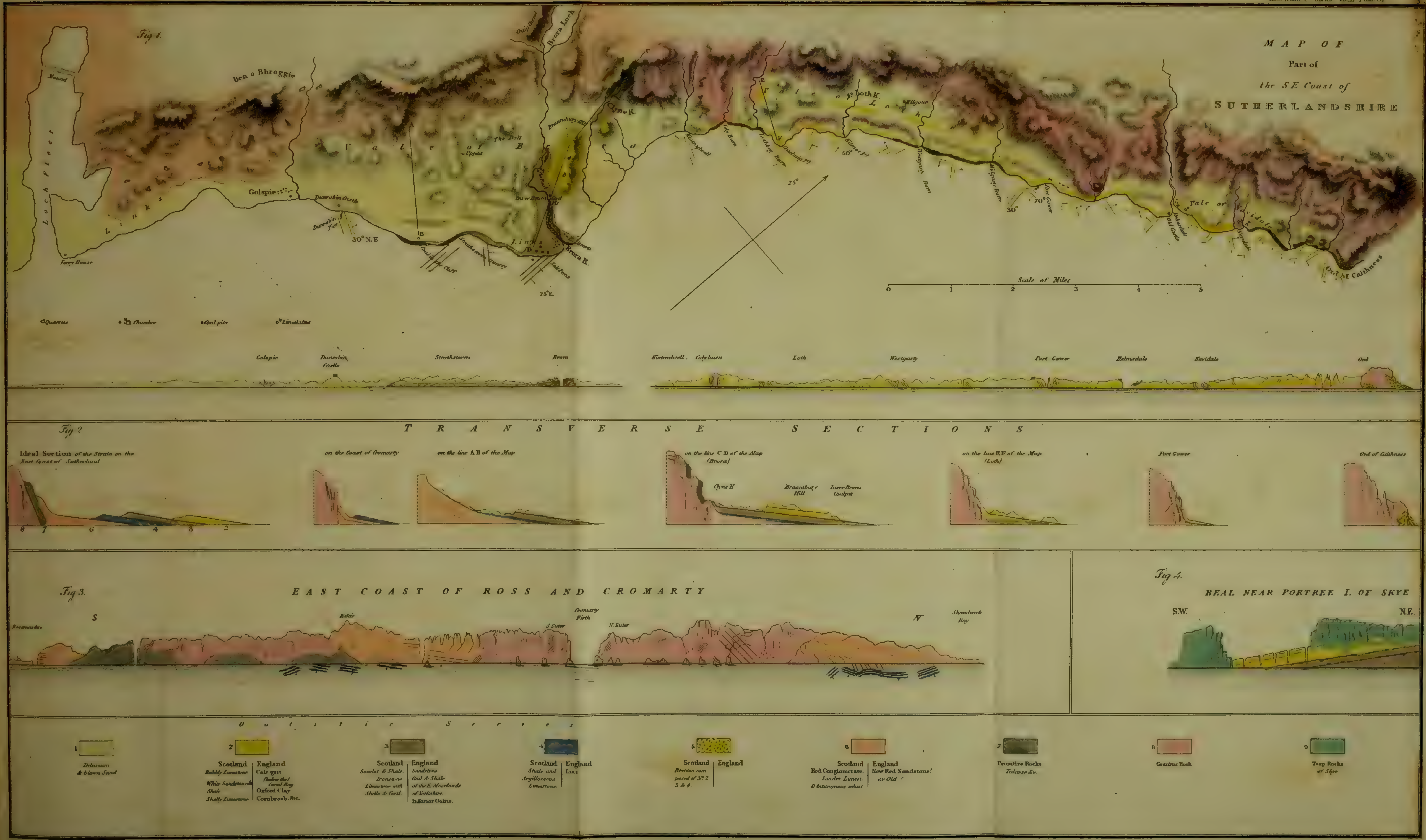
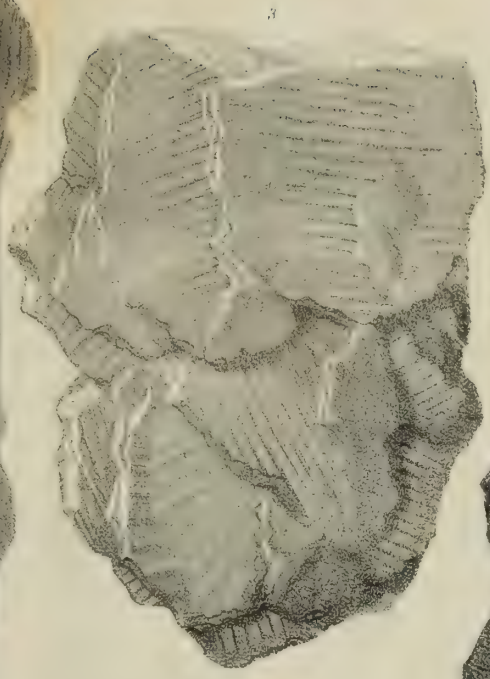


Fig. 1.
MAP OF
Part of
the S.E. Coast of
SUTHERLANDSHIRE
Ben a Bhraggie
Brora Loch
Golspie
Dunrobin Castle
Dunrobin Pier
Loch Fleet
Links
Ferry House
30° N.E.
Vale of B
The Doll
Uppat
Clyne K.
Brora R.
Links
Salt Pans
25° E.
Strathsteven Quarry
Kintradwell
Loth K.
Kilgour
Port Gower
Helmsdale
Old Castle
Vale of Navidale
Ord of Caithness
25°
50°
30°
70°
Scale of Miles
0 1 2 3 4 5
Quarries
Churches
Coal pits
Limekilns
Golspie
Dunrobin Castle
Strathsteven
Brora
Kintradwell
Colyburn
Loth
Westgarty
Port Gower
Helmsdale
Navidale
Ord
Fig. 2
TRANSVERSE SECTIONS
Ideal Section of the Strata on the East Coast of Sutherland
8 7 6 4 3 2
on the Coast of Cromarty
on the line A B of the Map
on the line C D of the Map (Brora)
Clyne K.
Braambury Hill
Inver Brora Coalpit
on the line E F of the Map (Loth)
Port Gower
Ord of Caithness
Fig. 3.
EAST COAST OF ROSS AND CROMARTY
S
N
Rosemarkie
Ethie
Cromarty Firth
S. Sutor
N. Sutor
Shandwick Bay
Fig. 4.
BEAL NEAR PORTREE I. OF SKYE
S.W.
N.E.
Oolitic Series
1 Diluvium & blown Sand
2 Scotland: Rubbly Limestone, White Sandstone & Shale, Shelly Limestone | England: Calc grit (below the) Coral Rag, Oxford Clay, Cornbrash &c.
3 Scotland: Sandst. & Shale, Ironstone, Limestone with Shells & Coal. | England: Sandstone, Coal & Shale of the E. Moorlands of Yorkshire, Inferior Oolite.
4 Scotland: Shale and Argillaceous Limestone | England: Lias
5 Scotland: Breccia composed of No. 2 3 & 4. | England
6 Scotland: Red Conglomerate, Sandst. Limest. & bituminous schist | England: New Red Sandstone! or Old ?
7 Primitive Rocks Talcose &c.
8 Granitic Rock
9 Trap Rocks of Skye

1 a

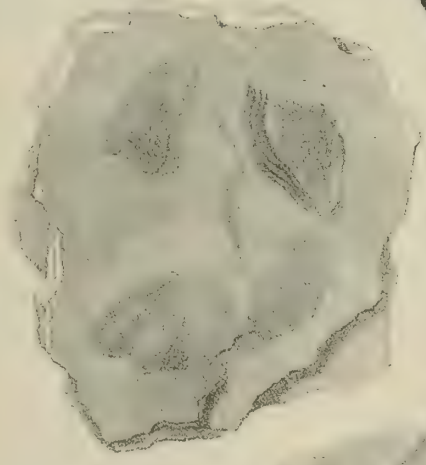
3



4

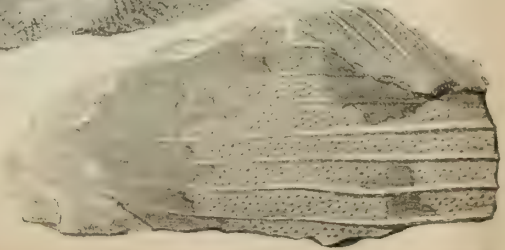
1 b

5

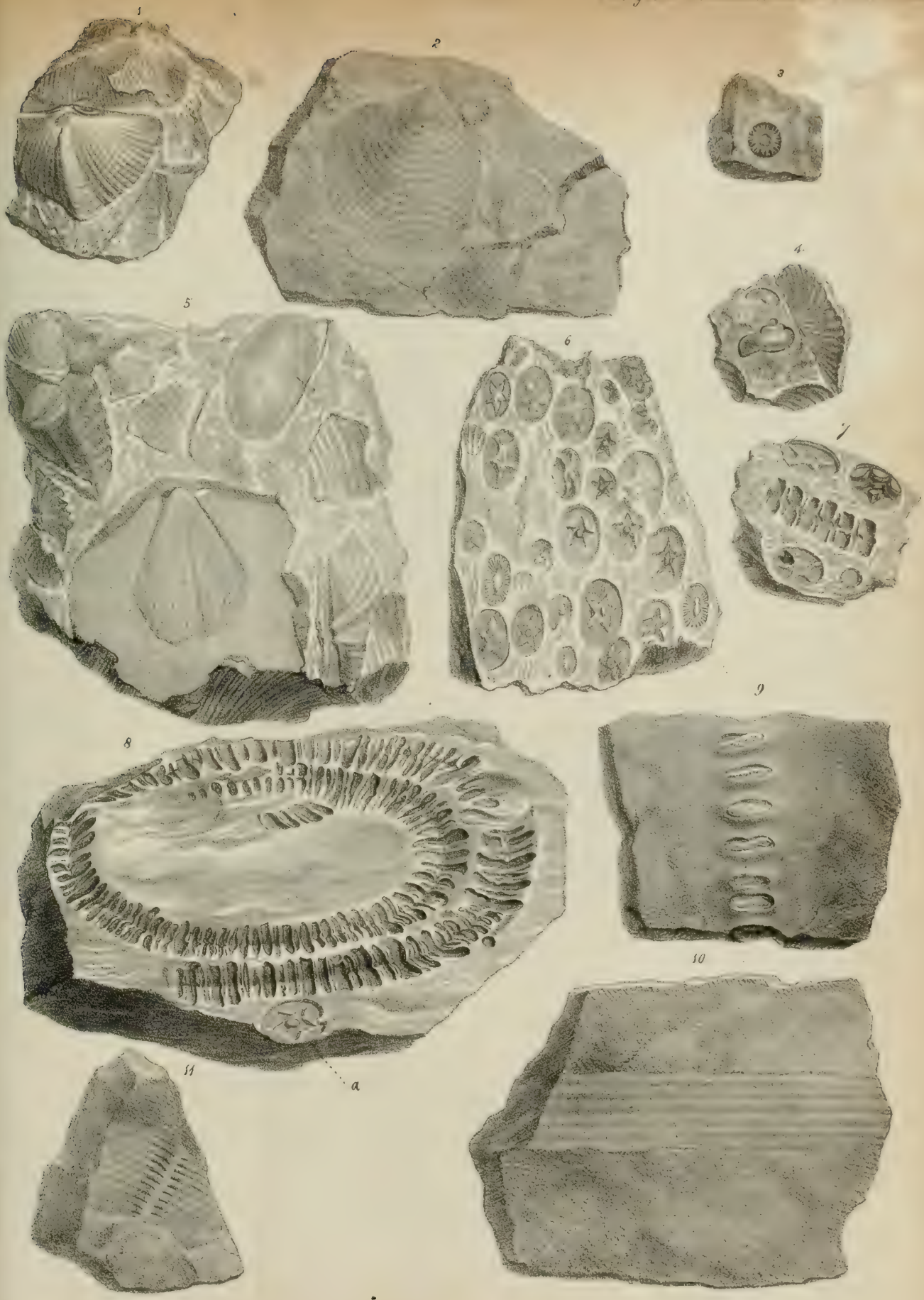


2

6



Printed by C. Hullmandel



...rfe lithog.

Printed by C. Hullmandel

Fig. 1.

Section open behind the Museo de studii at Naples
a hard Tufa. b loose d°. c strata of lapilla over lying made ground with Greek & Roman tombs

Fig. 2.

Fig. 3.

Monte Vico

Ischia from the West.

Town of Foria

Fig. 4.

Island and Crater of Nisida from the South.

Fig. 5.

Castle &c. Town of Ischia. Lava current del Arso. Monte Tabor. Casamicciola. Monte Vico

View of Ischia from the North.

Fig. 6.

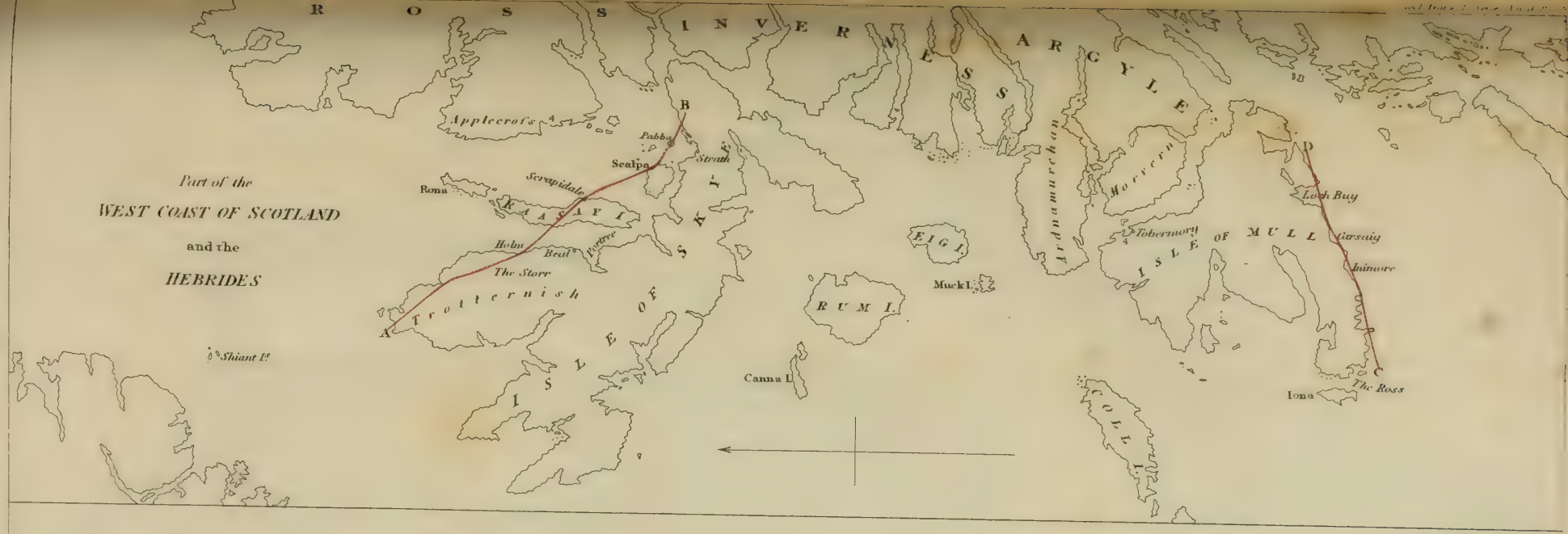
Monte di Procida from the South.

Scoglio delle Pietre arse. Vesuvius in the distance. Capo di Miseno.

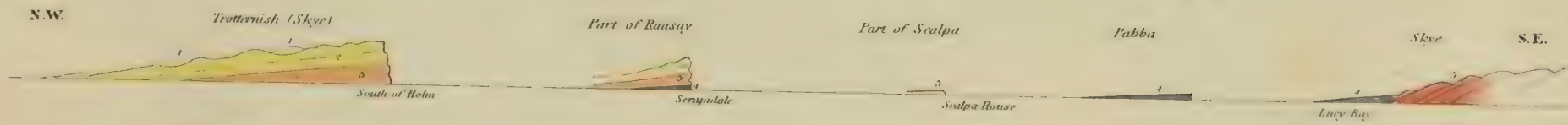
Bed of Trachytic Lava (Greystone)

Island of Procida from the West.

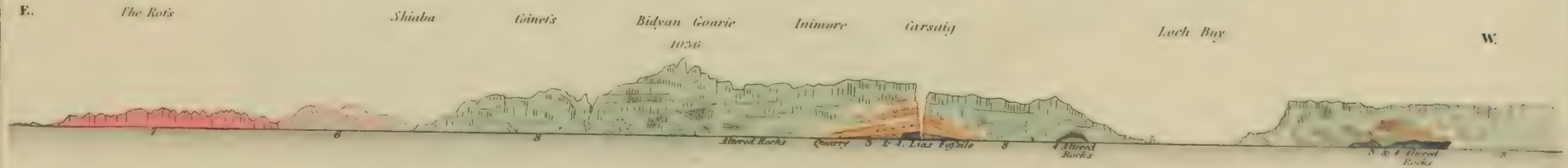
On the opposite side of this little Island is a very perfect Crater

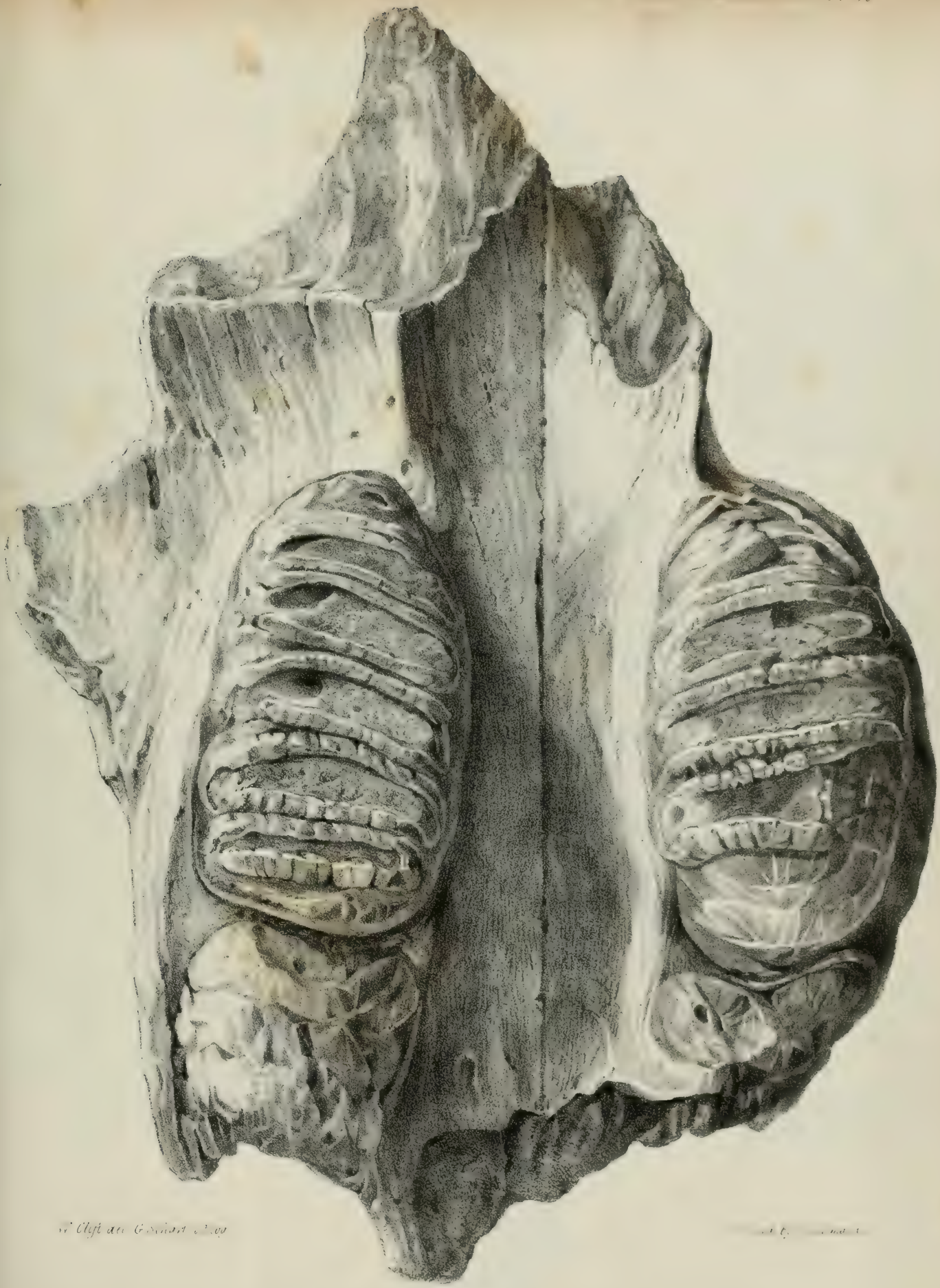


SECTION ON THE LINE AB OF MAP.



SOUTH COAST OF MULL ON THE LINE CD OF MAP.

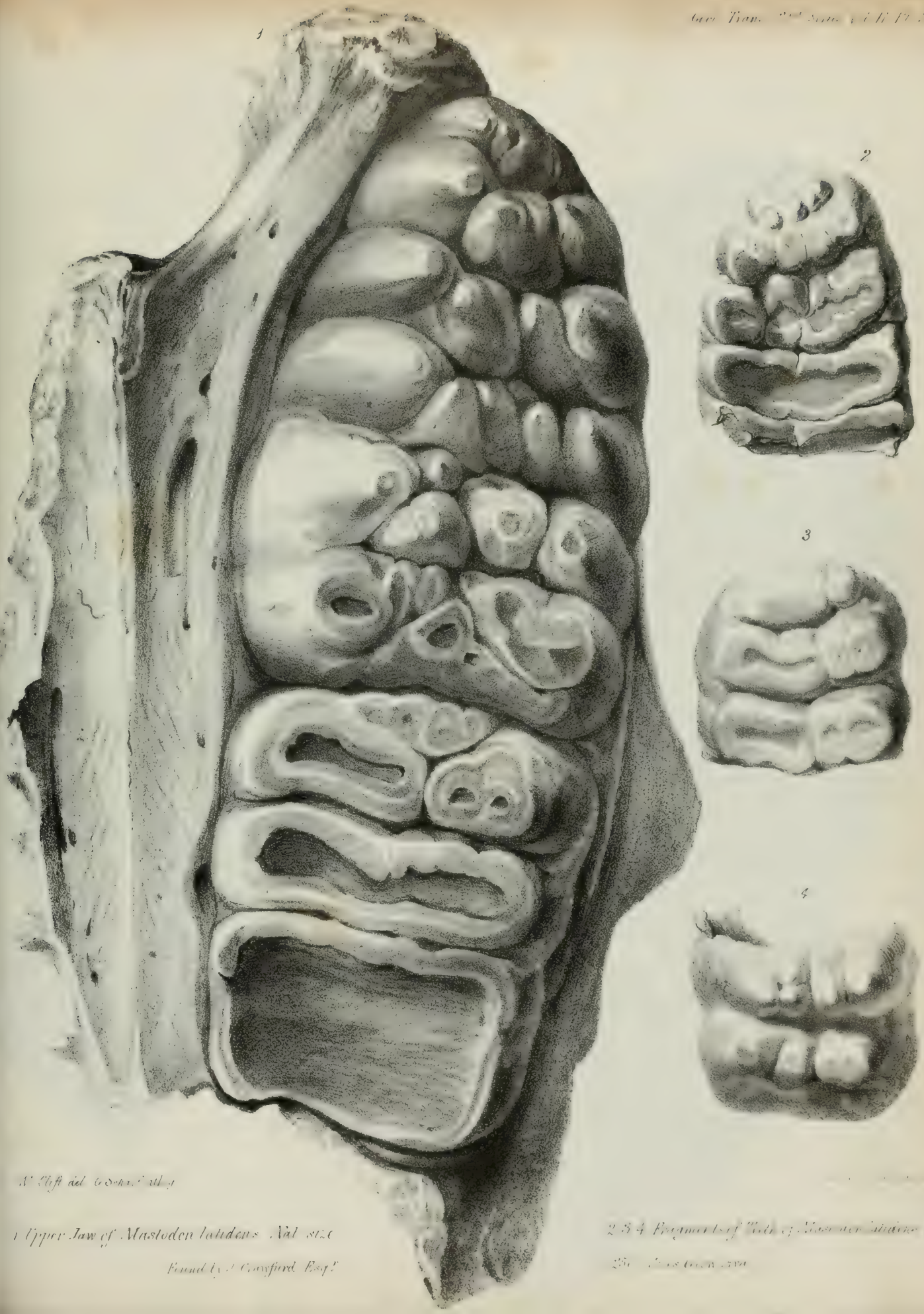




W. Clift del. G. Scharf Lith.

Upper Jaw of Mastodon latidens found by J Crawfurd Esqr. 250 Miles below Ava

[illegible] Natural Size



N. Clift del. & Schar. lith.

1 Upper Jaw of Mastodon latidens Nat. size

Found by J. Crawford Esq.r

2 3 4 Fragments of Teeth of Mastodon latidens ½ Nat. size

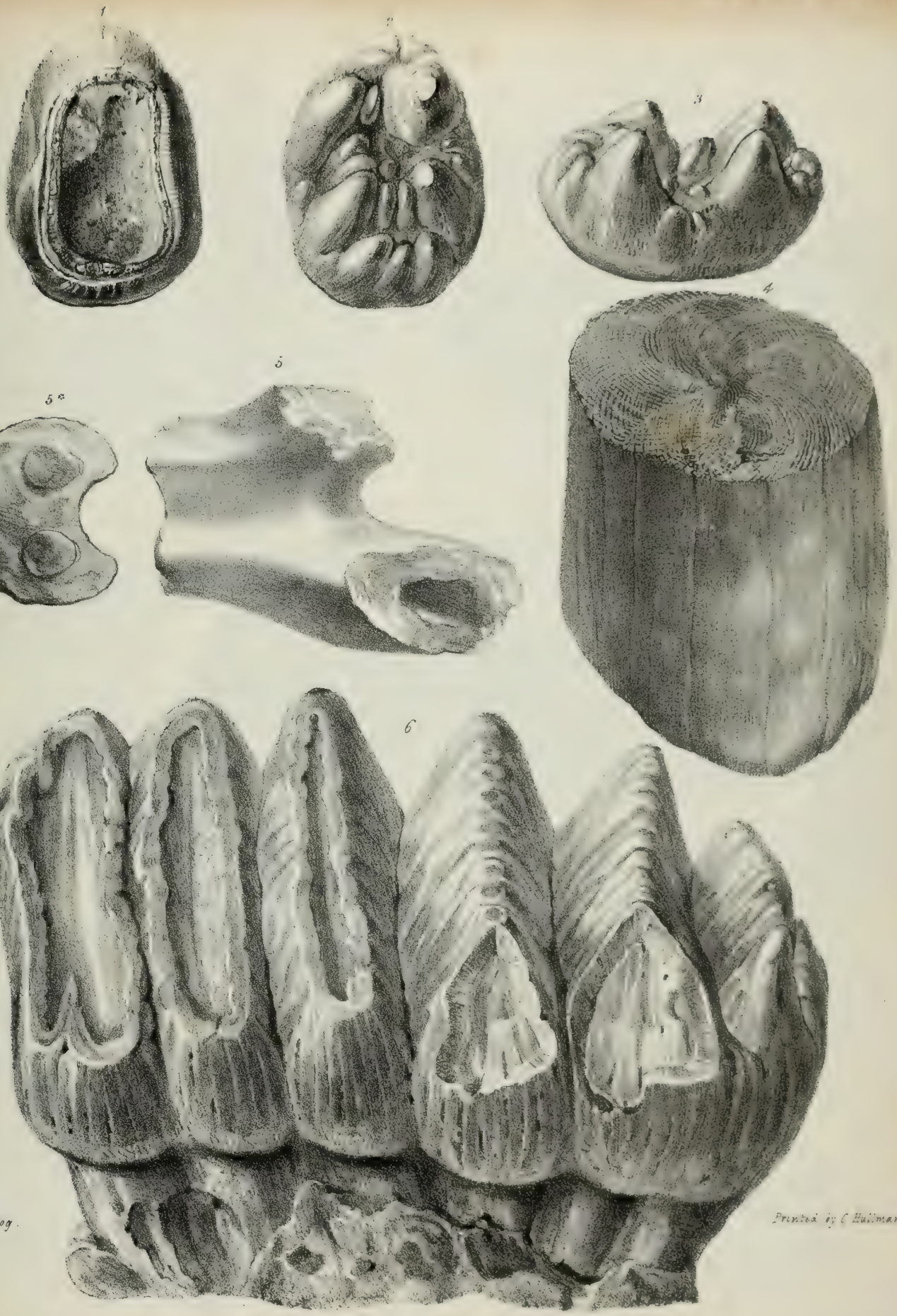
[illegible]

W Clift del G Scharf lithog

Printed by Hullmandel

1 Right Lower Jaw, Mastodon latidens 2 Left Lower Jaw. Mastodon Elephantoides ½ Nat size

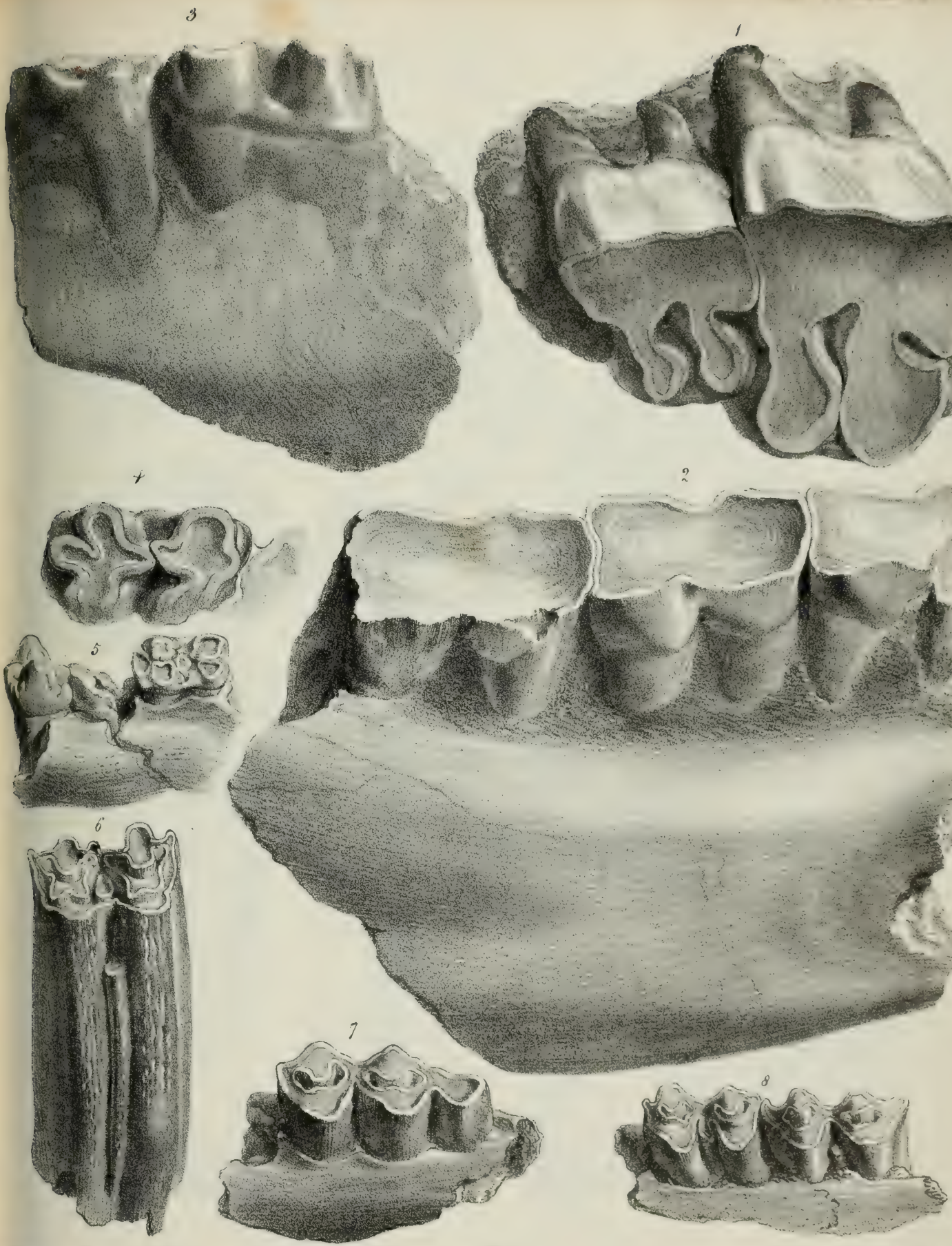
Found by J Crawfurd Esq.r 250 Miles below Ava



ft del G Scharf lithog.

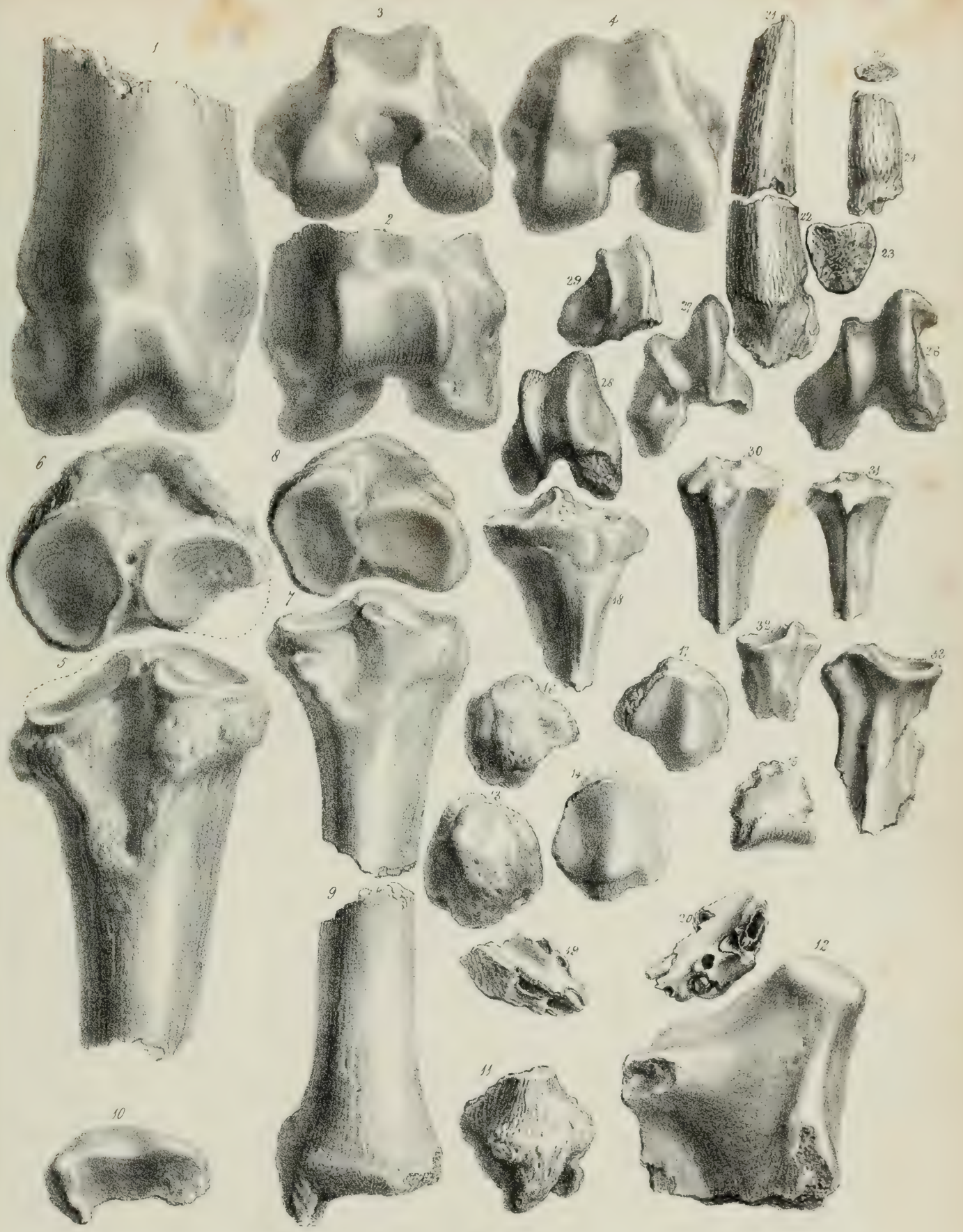
Printed by C Hullmandel

1 2 3 Milk Tooth of Mastodon 4 Tusk of Mastodon 5 Lower Jaw of Tapir 5* Front view of the same 6 Upper molar of M. Elephantoides



Drawn from Nature by G Scharf. Nat Size

1 Upper Jaw of Rhinoceros 2. Part of under Jaw of the same 3 Under Jaw of Hippopotamus 4 Teeth of ditto 5. Jaw of Hog
6 7. Molar Teeth of Ox 8. Molares of Deer. Found by J Crawfurd Esq.r 250 Miles below Ava

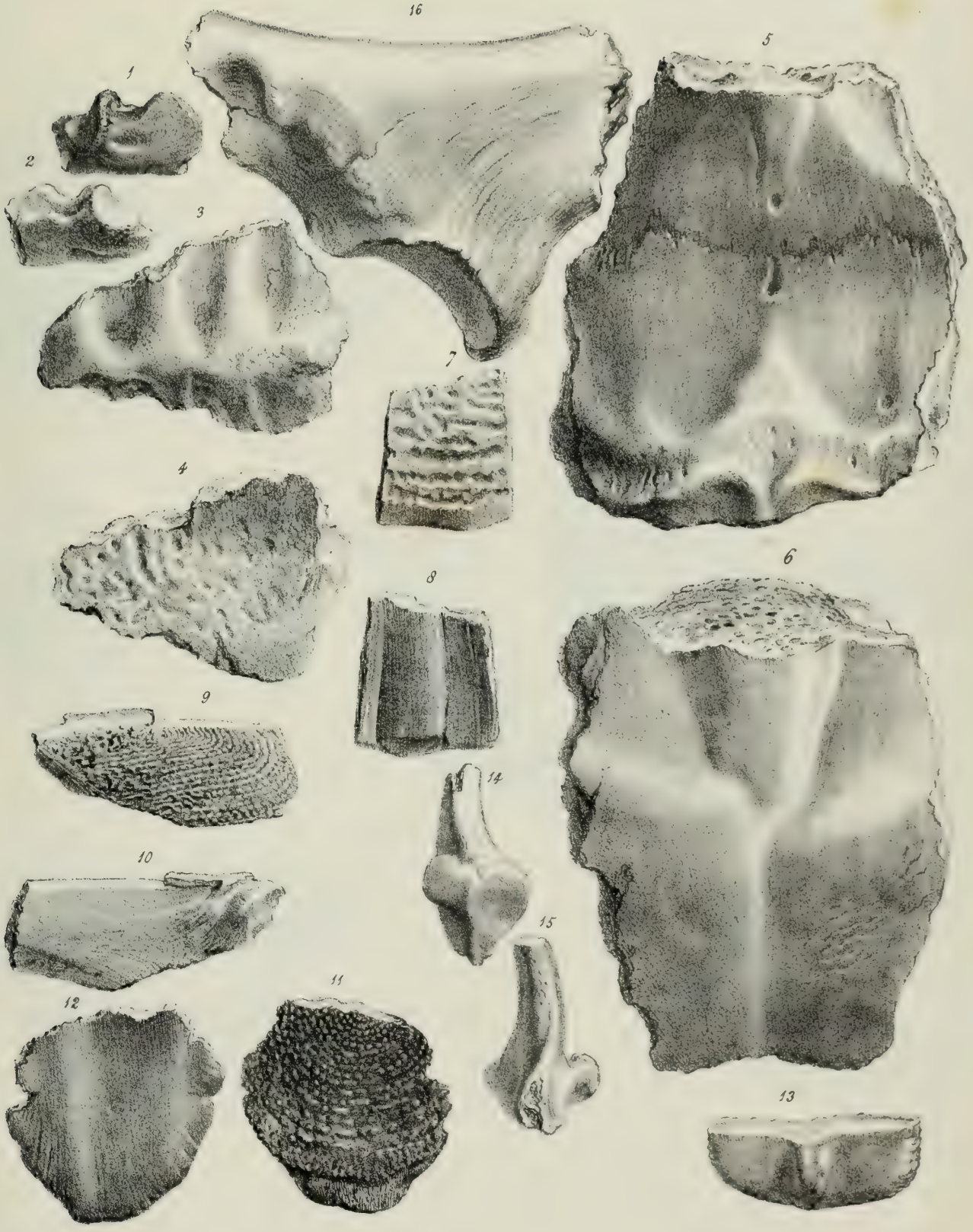


3 Nat. Size

Engraved from Nature by G. Scharf

Printed by C. Hullmandel

1 to 15 Bones of Mastoden latidens & Mastodon Elephantoides 16 17 18 26 Bones of Rhinoceros
19 20 Jaw of Hippopotamus 21 to 25 Horns of Antelopes. 27 to 33 Bones of Ruminantia

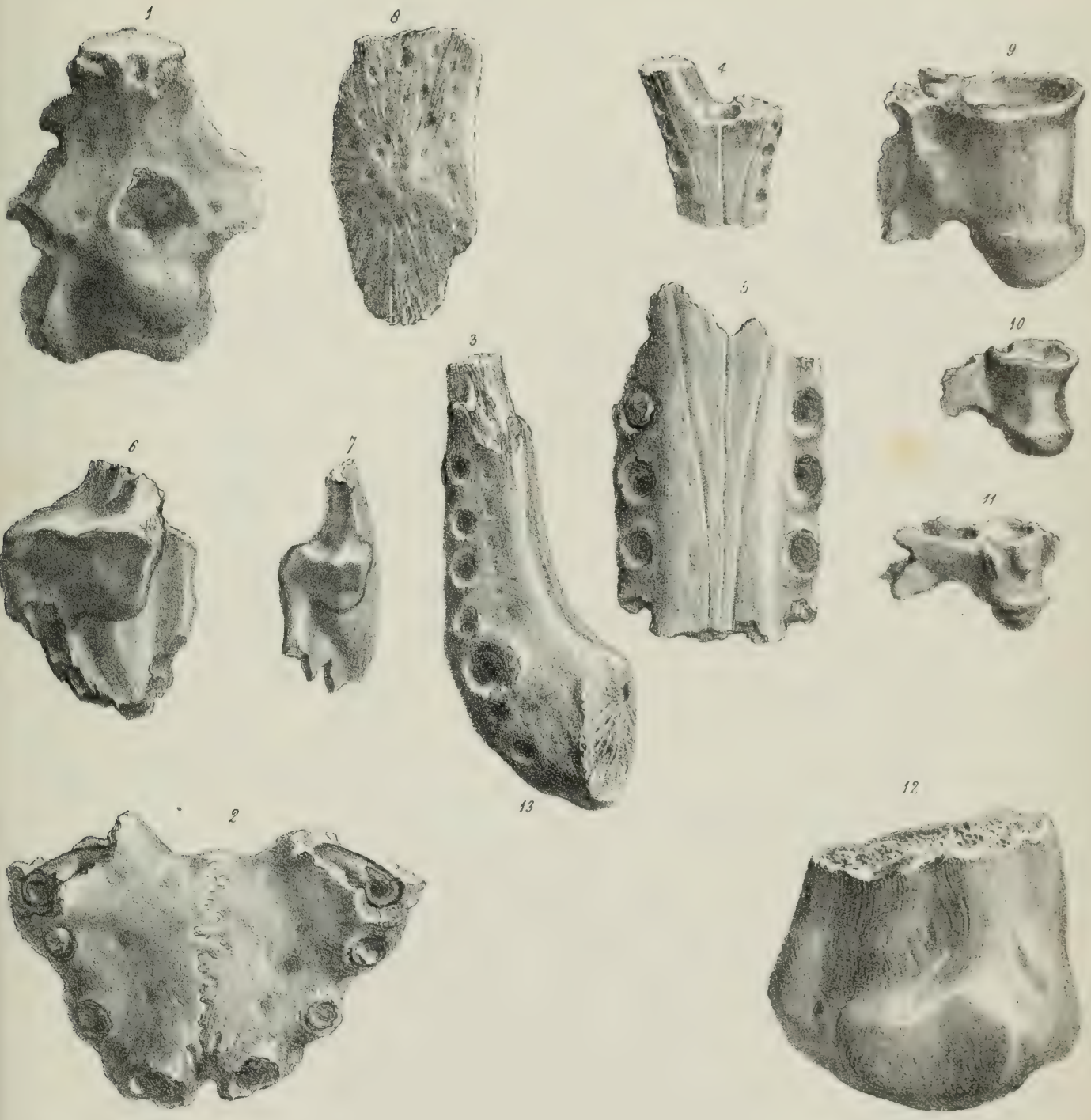


Lithographed from Nature by C Scharf

Printed by C Hullmandel

Remains of Fimys & Trionyx found by J Crawfurd Esq.r 250 Miles below Ava.

¼ Natural Size

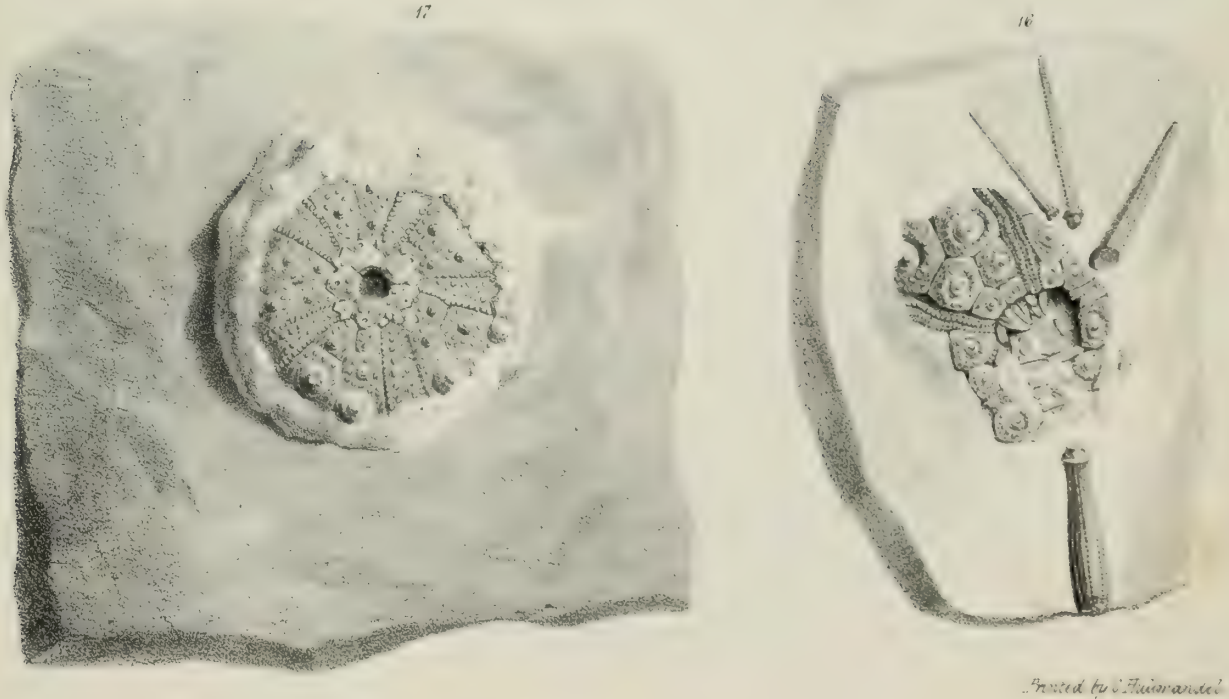


Engraved from Nature by C. Scharf

Remains of Crocodiles, found by J Crawfurd Esq.r 250 miles below Ava

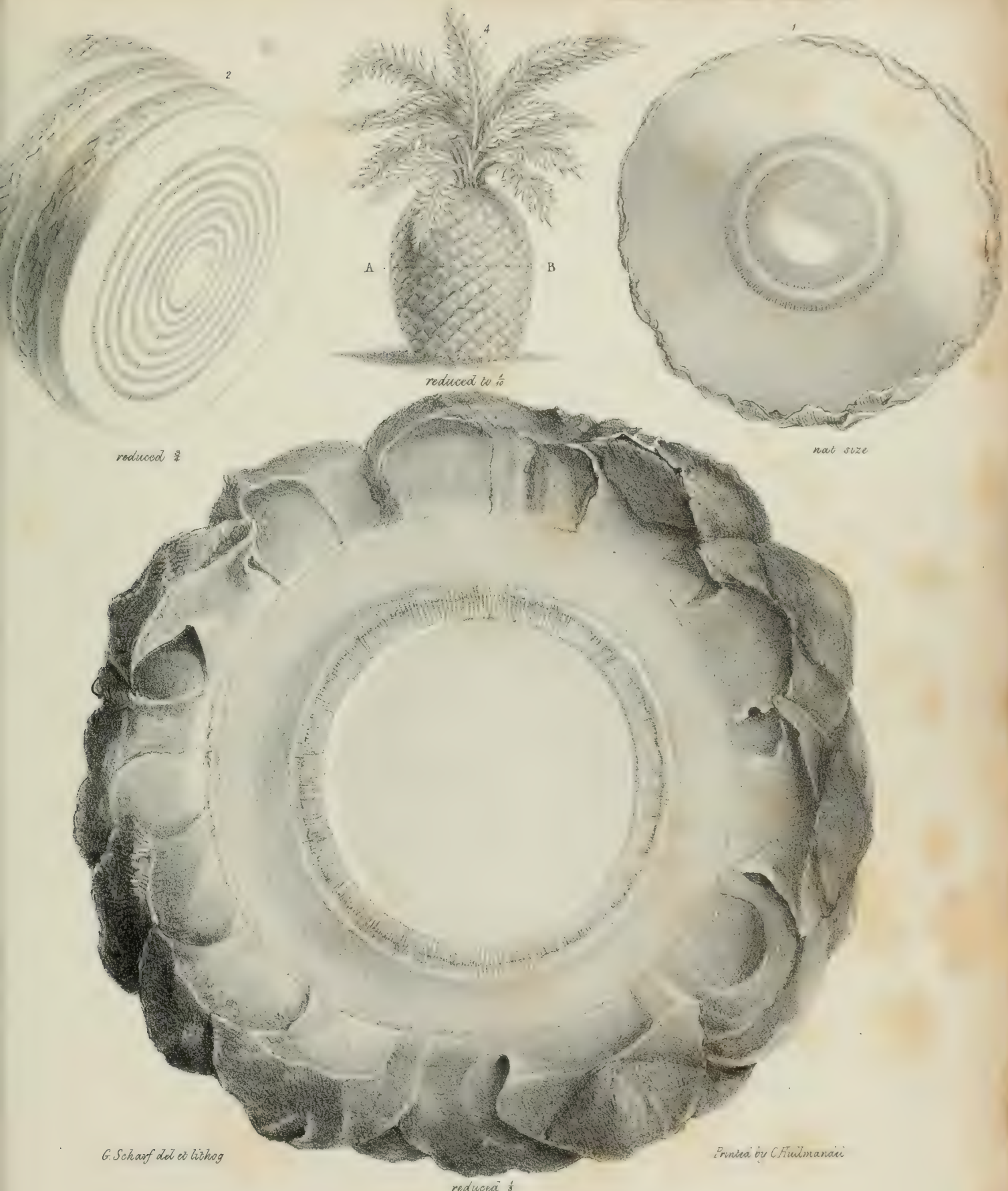
½ the Natural Size

MAP
Illustrative of
Mr. J. Crawfurd's
Journey to
AVA and MARTABAN,
in the Years
1826 and 1827
Alluvium of the Irawadi
Gravel & Sand containing Bones
Petroleum Springs and Lignite
Irawadi River
AVA
Pagan
PROME
Upper Country of the BURMANS
S I A M
P E G U E
RANGOON
Martaban
Blue Lime Stone
Bay of Bengal
Gulf of Martaban
94
95
96
97
98
99
22
21
20
19
18
17
16 N L.
94 E. L.

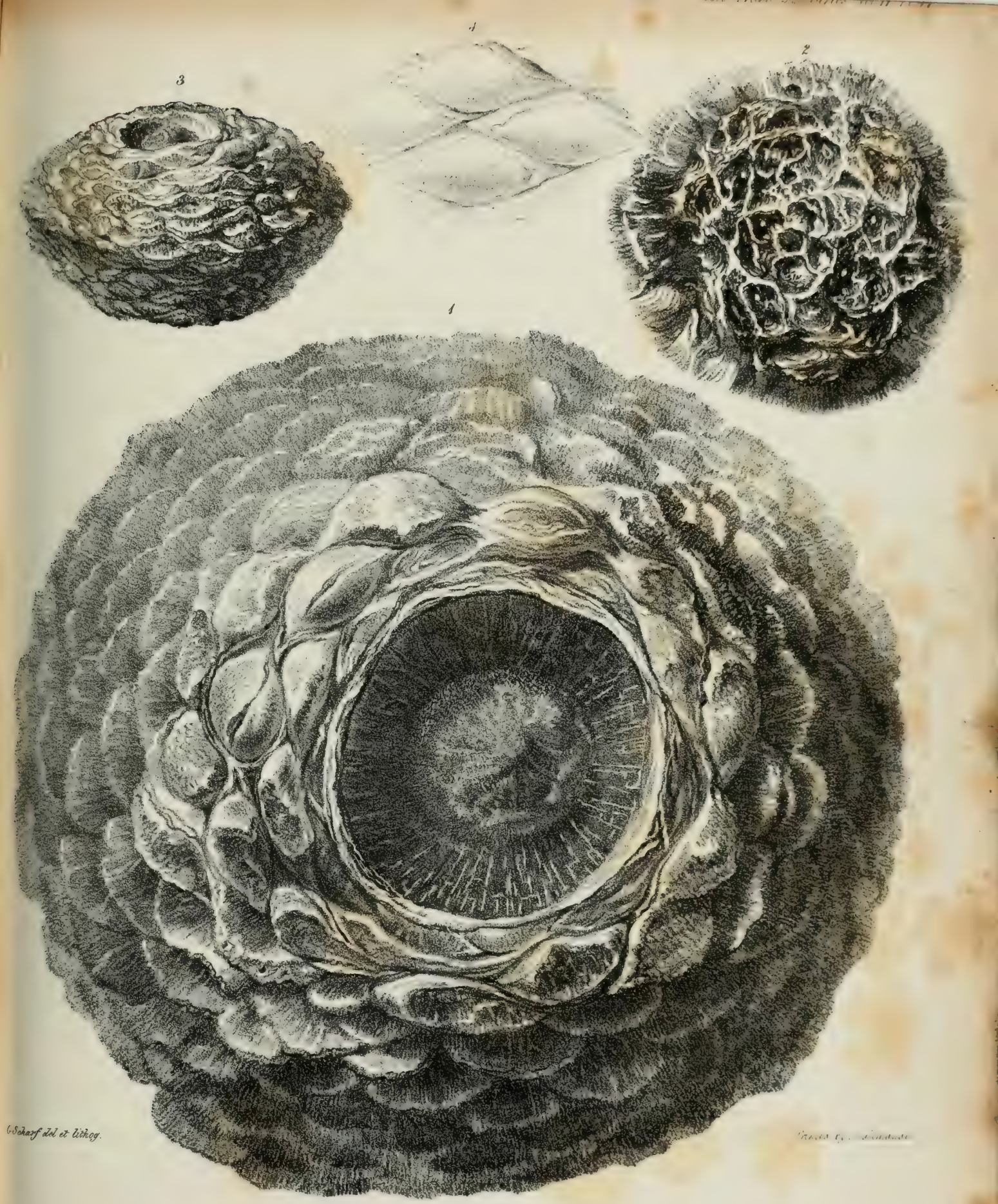


G. Scharf lithog.

Printed by J. Fairman del.

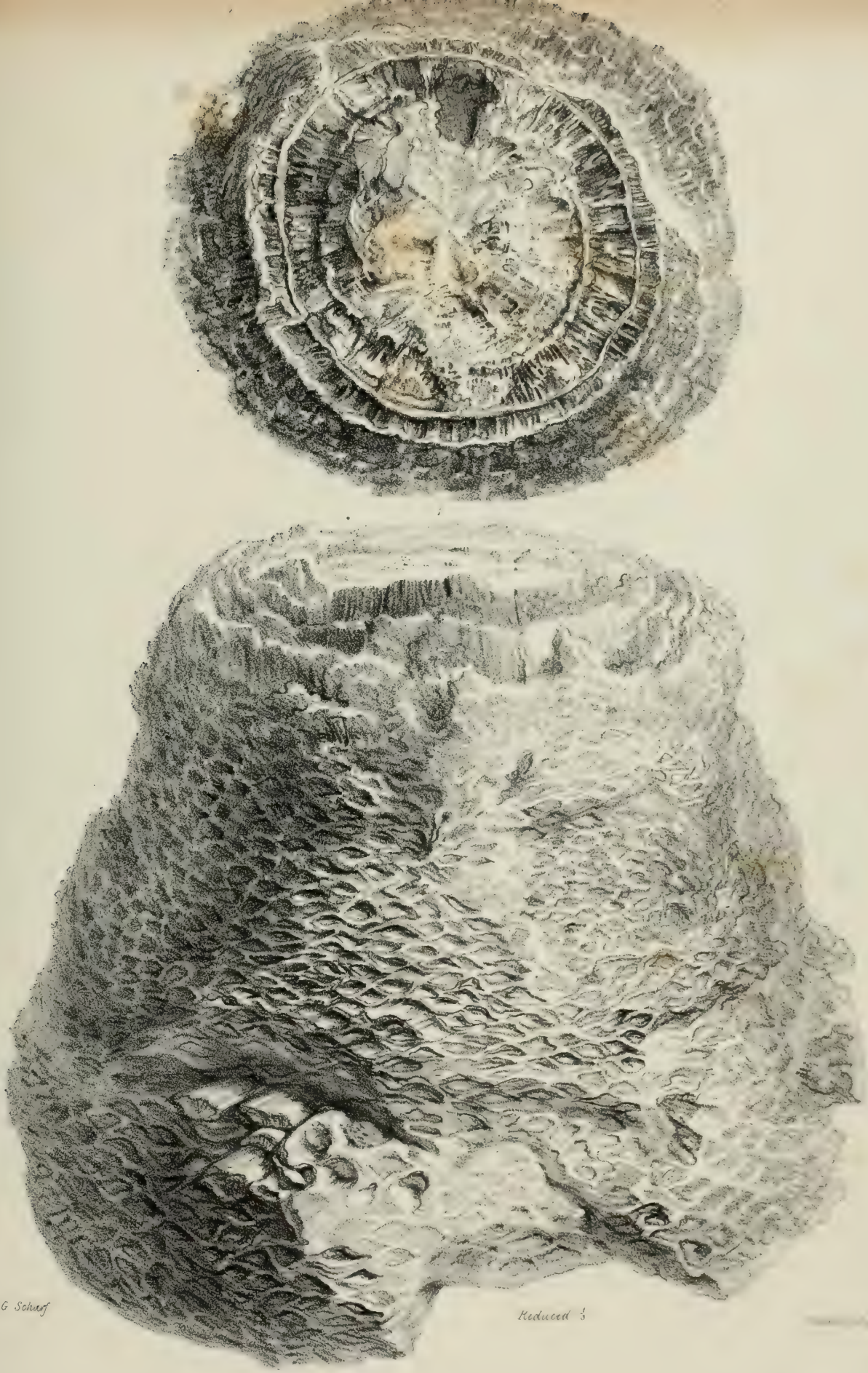


No. 1. Section near the Base of a Cycas revoluta, in possession of R. Brown Esq.r
2. Section of Cycas circinalis Todda-panna of Hortus Malabaricus. Vol. III. Pl. 21.
3. Section of Zamia Horrida, near the centre of the Caudex, taken at the line A.B. in Fig 4.



Cycadeoidea Megalophylla; silicified in the Portland Oolite, now in possession of Sir Geo Grey of Portsmouth
1. Top View, reduced ½. 2. Base at the commencement of the roots, reduced ½ 3. Side view, reduced ½. 4. Scars of

cadeoidea Megalophylla, silicified in the Portland Oolite, now in the Museum of Mr. Sowerby. 1. Section across the centre of the stem reduced $\frac{4}{3}$. 2. Magnified portion, at the junction of the plated and external cellular circles at A B C. 3. Junction of plated circle with external cellular ring & internal cellular substance, most distinct at the back of the specimen.



thog from Nat by G Scharf

Reduced ⅓

1 Cycadeoidea Microphylla, silicified in the Portland Oolite, now in the Museum of Mr. Sowerby, 2 Leaves reduced

CALIF ACAD OF SCIENCES LIBRARY
3 1853 10004 5702